National Aeronautics and  
Space Administration[illegible]

# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 212)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in March 1987 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



Scientific and Technical Information Office

**National Aeronautics and Space Administration**

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 493 reports, journal articles and other documents originally announced in March 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cumulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.



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## TYPICAL REPORT CITATION AND ABSTRACT

**NASA SPONSORED**

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ON MICROFICHE

ACCESSION NUMBER → **N87-10039\*** # National Aeronautics and Space Administration. ← **CORPORATE SOURCE**  
 Langley Research Center, Hampton, Va.

TITLE → **WIND-TUNNEL INVESTIGATION OF THE FLIGHT CHARACTERISTICS OF A CANARD GENERAL-AVIATION AIRPLANE CONFIGURATION** ← **PUBLICATION DATE**  
 ← **AVAILABILITY SOURCE**

AUTHOR → **D. R. SATRAN** Oct. 1986 ← 60 p

REPORT NUMBERS → **(NASA-TP-2623; L-15929; NAS 1.60:2623)** Avail: NTIS HC

PRICE CODE → **A04/MF A01 CSCL 01A** ← **COSATI CODE**

A 0.36-scale model of a canard general-aviation airplane with a single pusher propeller and winglets was tested in the Langley 30- by 60-Foot Wind Tunnel to determine the static and dynamic stability and control and free-flight behavior of the configuration. Model variables made testing of the model possible with the canard in high and low positions, with increased winglet area, with outboard wing leading-edge droop, with fuselage-mounted vertical fin and rudder, with enlarged rudders, with dual deflecting rudders, and with ailerons mounted closer to the wing tips. The basic model exhibited generally good longitudinal and lateral stability and control characteristics. The removal of an outboard leading-edge droop degraded roll damping and produced lightly damped roll (wing rock) oscillations. In general, the model exhibited very stable dihedral effect but weak directional stability. Rudder and aileron control power were sufficiently adequate for control of most flight conditions, but appeared to be relatively weak for maneuvering compared with those of more conventionally configured models.

Author

## TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

**NASA SPONSORED**

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ACCESSION NUMBER → **A87-11487\*** National Aeronautics and Space Administration.  
 Ames Research Center, Moffett Field, Calif.

**COMPUTATION OF TURBULENT SUPERSONIC FLOWS AROUND POINTED BODIES HAVING CROSSFLOW SEPARATION** ← **TITLE**

AUTHORS → **D. DEGANI and L. B. SCHIFF** (NASA, Ames Research Center, Moffett Field, CA) ← **AUTHOR'S AFFILIATION**

JOURNAL TITLE → **Journal of Computational Physics** (ISSN 0021-9991), vol. 66, Sept. 1986, p. 173-196. refs

The numerical method developed by Schiff and Sturek (1980) on the basis of the thin-layer parabolized Navier-Stokes equations of Schiff and Steger (1980) is extended to the case of turbulent supersonic flows on pointed bodies at high angles of attack. The governing equations, the numerical scheme, and modifications to the algebraic eddy-viscosity turbulence model are described; and results for three cones and one ogive-cylinder body (obtained using grids of 50 nonuniformly spaced points in the radial direction between the body and the outer boundary) are presented graphically and compared with published experimental data. The grids employed are found to provide sufficient spatial resolution of the leeward-side vortices; when combined with the modified turbulence model, they are shown to permit accurate treatment of flows with large regions of crossflow separation.

T.K.

# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 212)*

APRIL 1987

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## AERONAUTICS (GENERAL)

**A87-16726**

**NAECON 1986; PROCEEDINGS OF THE NATIONAL AEROSPACE AND ELECTRONICS CONFERENCE, DAYTON, OH, MAY 19-23, 1986. VOLUMES 1, 2, 3, & 4**

Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1986. Vol. 1, 395 p.; vol. 2, 300 p.; vol. 3, 418 p.; vol. 4, 350 p. For individual items see A87-16727 to A87-16853.

Papers are presented on digital technology and applications, avionics subsystems and weapon technology, and flight control technology. Consideration is given to software development and management, human interface with technology, and simulation and training. Topics discussed include command and control communications, aerospace engineering systems, and artificial intelligence. I.F.

**A87-16850**

**EXPERT MAINTENANCE DIAGNOSTIC SYSTEM FOR THE F-15 FLIGHT CONTROL SYSTEM**

J. DAVISON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), M. A. ALLSTADT, R. A. BELL, C. J. DITTMAR, L. G. HOFMANN (General Electric Co., Fairfield, CT) et al. IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1335-1342.

(Contract F33615-80-C-3600)

This paper reports development of a prototype expert system for F-15 Flight Control System maintenance diagnostic procedures. Particular emphasis is upon the extent and structure of the rule base, procedures for developing the rule base, and characteristics of the development environment and user interface. The purpose of this expert system application is to make all experts' knowledge of the flight control system available and accessible to the flight line technician, and by this means improve the technician's effectiveness and level of performance. This expert maintenance diagnostic system isolates failures below the Line Replaceable Unit (LRU) level; for example, connectors, wires and so forth. Reduction of the RTOK rate is a unique contribution of this system. This is achieved because of the sharper diagnostic procedures it can embody. Author

**A87-17022**

**COST EFFECTIVE TRANSPORTATION AND HIGH TECHNOLOGY**

J. M. SWIHART (Boeing Commercial Airplane Co., Seattle, WA) *Aeronautical Journal* (ISSN 0001-9240), vol. 90, Aug.-Sept. 1986, p. 249-261.

A comprehensive evaluation is made of the benefits of the intensive application of novel aerodynamic, structural and propulsion technologies to commercial aircraft. These technologies, which encompass boundary layer laminarization, aluminum-lithium

alloys, filament-wound composite shells, composite primary structures, thermoplastic resins, advanced digital avionics, and single and contrarotating rotor propfan engines, are aimed at reducing manufacturing and operating costs and improving such aspects of performance as fuel consumption and range. The most likely future configurations for subsonic and supersonic airliners are noted. O.C.

**A87-17142#**

**NATIONAL AERO-SPACE PLANE - TECHNOLOGY FOR AMERICA'S FUTURE**

R. M. WILLIAMS (DARPA, Arlington, VA) *Aerospace America* (ISSN 0740-722X), vol. 24, Nov. 1986, p. 18-22.

The objectives of the National Aero-Space Plane (NASP) program are discussed. The NASP program is to develop and test the technologies necessary for the development of military and civil vehicles capable of operating at sustained hypersonic speeds within the atmosphere and/or operating as space launch vehicles for delivering payloads into orbit. Technologies being developed include: air-breathing propulsion and engine components; high-strength, high-temperature, light-weight, fully reusable materials; structural and propulsion design codes; high-efficiency energy management of the hydrogen fuel; and advanced computer and adaptive-intelligence control systems. I.F.

**A87-17705**

**FROM THE HISTORY OF SOVIET AVIATION: ILYUSHIN AIRCRAFT [IZ ISTORII SOVETSKOI AVIATSII: SAMOLETY OKB IMENI S.V. IL'YUSHINA]**

G. V. NOVOZHILOV, D. V. LESHCHINER, V. M. SHEININ, M. S. BOLSHAKOV, S. I. DMITRIEV et al. Moscow, Izdatel'stvo Mashinostroenie, 1985, 288 p. In Russian. refs

The development of military and civilian Il-aircraft over a period of fifty years is reviewed. Particular attention is given to bombers and attack aircraft known chiefly for their use in WW II; the Il-4, Il-6, Il-22, Il-28, Il-30, Il-46, Il-54, Il-2, Il-10, Il-16, Il-8, and Il-20 are considered. Also examined are a number of passenger and cargo aircraft. The design and performance of the Ilyushin aircraft are examined, with special attention given to questions of weight design. B.J.

**A87-17707**

**M. V. KELDYSH: SELECTED WORKS - MECHANICS [M. V. KELDYSH: IZBRANNYE TRUDY - MEKHANIKA]**

K. I. BABENKO, ED., G. P. SVISHCHEV, ED., and N. N. CHENTSOV, ED. Moscow, Izdatel'stvo Nauka, 1985, 568 p. In Russian. No individual items are abstracted in this volume.

The present volume contains the main body of original work by M. V. Keldysh, as well as some scientific reviews, in the fields of aerohydrodynamics, aeroelasticity and self-oscillations of aircraft structures, and explosion gas dynamics. In particular, papers are presented on the external Neumann problem for nonlinear elliptic equations with an application to the theory of a wing in a compressible gas; the motion of a wing over the surface of a heavy fluid; some new problems in the theory of wing vibration; and a method for calculating wing flutter. V.L.

## A87-17896#

### LESSONS LEARNED FROM THE B-52 PROGRAM EVOLUTION - PAST, PRESENT AND FUTURE

L. T. MONTULLI (Boeing Military Airplane Co., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. (AIAA PAPER 86-2639)

**A87-17897\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### BOMBER DESIGN TRENDS

M. L. SPEARMAN (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 20 p. refs (AIAA PAPER 86-2640)

Some basic trends in bomber aircraft are traced from the pre-World War I era to the present time. The historic review includes bombers of many countries. The primary discussion, however, will be based on U.S. bomber programs and, to the extent possible, on USSR bomber programs. The bomber aircraft will be examined in terms of performance and mission capability. Characteristics will include power or thrust loading, wing loading, maximum speed, cruising speed, weight and weight distribution, and payload. These trends can be used to indicate the rationale for certain design types. Performance characteristics can be used to indicate potential mission objectives. The overall design trends should be useful in revealing the influence of mission objectives, the influence of advanced technology and, in turn, may be useful in predicting likely future trends. Author

## A87-17905#

### FIGHTER AIRCRAFT/PROPULSION INTEGRATION

P. W. HERRICK (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 12 p. refs (AIAA PAPER 86-2658)

The effects of the integration of flight propulsion systems into fighter aircraft are traced from the early days of flight to the foreseeable future. The types and locations of engines, inlets, nozzles, engine/propulsor installations, and cooling systems are shown to affect the thrust, drag, weight, volume, and performance of installed airbreathing propulsion systems. These, in turn, are shown to impact the configuration, performance, stability and control, speed, lethality, fuel consumption, maneuverability, reliability and maintainability, safety, survivability, and pilot workload of the overall fighter aircraft system. These relationships are discussed with respect to representative fighter aircraft types ranging all the way from World War I to the 21st century. Author

## A87-17908#

### THE F-16 - A MODEL FOR MAXIMUM DESIGNED-IN SUPPORTABILITY

R. K. THOMPSON (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. (AIAA PAPER 86-2663)

The military and industry now have the collective objective of minimizing the high cost of weapon system ownership. The F-16 program is an excellent example of successful efforts to achieve this objective. Major emphasis was placed on life-cycle cost, reliability, maintainability, and supportability. This collective effort began with the early low-cost fighter concept studies and has continued throughout the design, development, production, and operational use of the F-16. This article focuses on the close attention given to the design-for-supportability approach, a principal contributor to the success of F-16 supportability. Author

## A87-17909#

### SUPPORTABILITY INTO DESIGN - THE MCAIR EXPERIENCE

M. A. LEONE (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. (AIAA PAPER 86-2664)

This paper describes the evolution of supportability integration into the design and program management of McDonnell Aircraft products. Logistics characteristics are traced from the 1950's through the present F-15, F/A-18, and AV-8B programs and postulated for known programs through the turn of the next century. Author

**A87-17914\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### THE EFFECT OF ADVANCED TECHNOLOGY ON THE SECOND-GENERATION SST

P. G. COEN (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 5 p. (AIAA PAPER 86-2672)

Technological developments that promise to substantially increase the efficiency of next-generation subsonic commercial aircraft, together with additional developments in supersonic aircraft aerodynamics, structures and propulsion systems, are presently evaluated in order to project the extent of performance and economic improvement obtainable for a future SST by comparison to the Concorde SST. It is demonstrated that the second-generation SST projected will double passenger-carrying capacity from 100 for the Concorde to 200, despite reducing takeoff gross weight from 400,000 to 321,000 lbs and extending range by some 2000 nm. O.C.

## A87-17918#

### THE INFLUENCE OF USAGE SPECTRUM AND MULTI LIFT ON THE EFFICIENT SIZE OF A CARGO ROTORCRAFT

W. H. MEIER and J. R. OLSON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. refs (AIAA PAPER 86-2677)

A methodology is described for assessing the influence of usage spectrum and multi lift operation on the efficient size of a cargo rotorcraft. For characteristic distributions of required payload, sortie radius, and ambient conditions, it is shown that use of multi lift for a small percentage of missions could permit aircraft size to be significantly reduced, with a corresponding improvement in overall productivity. The 'best' aircraft size is very sensitive to the usage spectrum and to the acceptable frequency of multi lift operation, both of which need to be realistically defined. Author

**A87-17944\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### AIRCRAFT RESEARCH AND DEVELOPMENT TRENDS IN THE US AND USSR

M. L. SPEARMAN (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 14 p. refs (AIAA PAPER 86-2720)

Research and development related to aircraft has shown significant progress in both the U.S. and the USSR. In some cases, the indications are that technological advances have resulted in new aircraft concepts and, in other cases, there are indications of particular national needs or objectives that have driven the required research and development to meet the need. The progression of aircraft development tends to reflect factors other than technology such as the political atmosphere, the world environment, and other contending national objectives. The trends in aircraft research and development in the U.S. and USSR will be traced from the early 1900's and, in a time-frame manner, will be related to other influencing factors. Author

A87-17946#

**COMMUTER, CORPORATE AND LIGHT AIRCRAFT - ANALYSIS OF INTERNATIONAL OPERATIONS AND MARKETS**

R. R. TRACY (Flightcraft Co., Reno, NV) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. refs  
(AIAA PAPER 86-2724)

The relative importance of General Aviation (G-A) in the worldwide civil aviation picture is considered in terms of aircraft fleet size and flying hours. These indices are analyzed for six global regions defined by ICAO. It is found that: (1) G-A accounted for 90 percent of reported civil aircraft worldwide and 62 percent of civil flying hours in 1984; (2) the U.S. operated 90 percent of the world's reported G-A aircraft and accounted for 71 percent of all G-A flying hours in 1984; (3) turbine airplanes, while comprising only 4 percent of the U.S. G-A fleet in 1984, generated most of the new airplane sales revenue in the U.S.; and (4) non-U.S. firms dominate the design and manufacture of commuter aircraft. K.K.

A87-18197

**BRITISH AIRWAYS EXPERIENCE WITH COMPOSITE REPAIRS**

K. B. ARMSTRONG (British Airways, Hounslow, England) IN: International Conference on Structural Adhesives in Engineering, Bristol, England, July 2-4, 1986, Proceedings. London, Mechanical Engineering Publications, Ltd., 1986, p. 183-190. refs

This paper describes British Airways experience with composite repairs since 1970. It includes the use of composite materials to repair metal structures such as Concorde wing leading edges and traces the repair of composite parts from Radomes starting in 1970, through B747 body fairings and floor panels, to the repair of carbon fiber composite control surfaces and access doors on the B757. Most of the repairs have used cold-setting resins (with heat lamp assisted curing) but some hot-setting adhesives and pre-preps have been used. Author

A87-18643

**WHAT'S YOUR HEADING?**

I. GOOLD Flight International (ISSN 0015-3710), vol. 130, Sept. 20, 1986, p. 32-34.

Current trends in the general aviation market are discussed. The factors which are affecting the current sales of aircraft and the number of student pilots, such as high aircraft prices, the value of the dollar, and the exchange rate, are examined. The relationship between changes in the U.S. economy and general aviation deliveries is studied. Consideration is given to rising fuel, operation, and maintenance costs. I.F.

A87-19201

**AMERICAN HELICOPTER SOCIETY, ANNUAL FORUM, 42ND, WASHINGTON, DC, JUNE 2-4, 1986, PROCEEDINGS. VOLUMES 1 & 2**

Alexandria, VA, American Helicopter Society, 1986. Vol. 1, 566 p.; vol. 2, 621 p. For individual items see A87-19202 to A87-19289.

The present conference addresses topics in the dynamics of helicopters, their military operations, and their aerodynamics, structures, and materials, as well as such associated issues as those of helicopter product support by manufacturers, structural dynamic system identification techniques, and rotorcraft acoustics. Attention is given to the automated tuning of airframe vibration by structural optimization, the effects of gun accuracy and rotorcraft maneuverability on air-to-air combat effectiveness, innovative composite structures manufacture tooling, the V-22 tilt-rotor aircraft, basic research in structural dynamic system identification, and acoustic propagation studies employing CFD. O.C.

A87-19210

**THE EFFECTS OF GUN ACCURACY AND ROTORCRAFT MANEUVERABILITY ON AIR-TO-AIR COMBAT EFFECTIVENESS**

K. W. HARVEY (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 129-142.

A computer simulation of multiple rotorcraft air-to-air combat is presented. Each rotorcraft is modeled at the predesign level of detail. The rotor analysis includes the rotor-rpm and flapping degrees of freedom. Armament suites include missiles, guns, turret and sensor limits, firing logic, and vulnerable areas. Damage is assessed by two-sided dueling logic, and the exchange ratio (kills/losses) is used to evaluate force effectiveness. Each rotorcraft is flown over flat earth by an aggressive, analytically-modeled pilot in a series of adaptive maneuvers to exploit its maneuverability. A version with 3-D terrain and two men-in-the-loop is also presented. Engagements between two opposing forces (M versus N) show the importance of the number of participants on each side. The effects of fire-control system accuracy, turret travel limits, and the trade of kinetic energy for an altitude advantage are evaluated parametrically. Author

A87-19213

**MODEL FOR ANALYSIS OF COMBAT SUSTAINABILITY**

T. N. COOK (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 157-166.

MACS (Model for Analysis of Combat Sustainability) is a computer model developed by Sikorsky Aircraft under independent research and development (IR&D). Its purpose is to assess the survivability of helicopters operating against small-arms threats of varying intensity and to predict the effects of small-arms damage on aircraft combat maintenance and battle-damage repair. Sustainability factors generated by MACS are used by Sikorsky's CMS (Combat Maintenance Simulator) model to evaluate the mission availability and sortie-generation capability of a helicopter fleet operating in a particular threat scenario. Author

A87-19216

**V-22 TILT ROTOR TRANSITION STRUCTURE FABRICATION AND ASSEMBLY**

D. L. PETERSEN (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 177-182.

An account is given of the construction and assembly methods applied to the V-22 tilt rotor aircraft's spindle/pylon support assembly, which is the main connection and rotation point of the engine nacelle on the wing. Both carbon/epoxy and fiberglass/epoxy roving and unidirectional tape are used in this complex, contoured composite structure, thereby requiring hand layups to create the thick structural sections required. The development process required the evaluation of various tooling approaches, winding techniques, compaction procedures, and cure cycles. O.C.

A87-19229

**STRENGTHENING THE WEAK LINK OF FATIGUE QUALIFICATION**

K. M. ROTENBERGER (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 339-344.

The 'weak link' in the fatigue substantiation process is the aircraft usage spectrum. In recognition of this, the Army is conducting several programs designed to better account for the actual usage of Army helicopters. A pilot survey program was conducted for the AH-1 and UH-1 systems and produced updated spectra that incorporated new missions and tactics previously unaddressed. Many programs involving flight Data Recorders are

currently underway. They are designed to record the data necessary to continuously define the condition of an aircraft in flight. Once incorporated, this will allow the Army to monitor and update usage spectra as necessary and thereby enhance the 'weak link' of the fatigue substantiation process. Author

**A87-19233**

## **A DESIGN-SUPPORT TEAM VIEWS FORTY YEARS OF COMMERCIAL HELICOPTER VALUE**

G. M. POWELL and F. J. WAGNER (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 375-388.

Attention is given to differences in value between today's commercial helicopters and those of the past 40 years. Product value trends are examined in detail using the 206 single engine turbine series as the representative commercial helicopter. It is concluded that today's helicopter provides much better value due mostly to increased reliability and safety. Over the last five years, the direct operating cost is constant to declining. Liability insurance for the manufacturers emerges as the only regressive trend of value. K.K.

**A87-19235**

## **LOGISTICS/ENGINEERING COMMUNITY COOPERATION - A CASE STUDY**

C. LUCHUN, P. H. RENSON (Avco Lycoming Textron, Stratford, CT), J. P. DEMASE, and C. E. LANGSTON, JR. (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 409-412.

With the increased recognition of Life Cycle Cost in today's market place, it has become evident that a new approach to doing business is required. Many companies are teaming together to consolidate their resources in order to provide the best available products. Such is the case for two industry leaders, AVCO Lycoming and Pratt and Whitney, who have teamed to develop the T800-APW-800 engine for the U.S. Army's LHX helicopter. Their innovative approach to incorporating Reliability, Availability, Maintainability/Integrated Logistics Support/Manpower Personnel Integration (RAM/ILS/MANPRINT) characteristics early in the design phase will insure an end product that meets the customer's requirements. Author

**A87-19236**

## **SUPPORTABILITY AND AIRCRAFT DESIGN**

M. A. BARNES (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 413-418.

Schedule, cost, weight, and performance are not the only constraints which influence design requirements and specifications. Supportability concerns and establishment of an effective ILS program pursuing the objective of fielding a supportable aircraft also influence the design from concept formulation to fielding. This paper deals with the application of Logistic Support Analysis to the multiservice V-22 Program. Bell-Boeing V-22 logistics and maintenance planners are exercising established methods of analysis and identifying support concepts and alternatives to maximize operational readiness in the fleet. Author

**A87-19248**

## **AHIP - THE OH-58D FROM CONCEPTION TO PRODUCTION**

F. D. HARRIS (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 587-596.

The major aspects of a full scale engineering development (FSED) program initiated as a result of industry participation in the Army Helicopter Improvement Program (AHIP) are presented. As a result of this program, five OH-58A helicopters were converted to OH-58D's, and the first two production aircraft were delivered.

The transition from FSED design to OH-58D production is discussed, together with technical lessons learned from AHIP and recommendations to teams involved in future Army helicopter development programs. I.S.

**N87-13401#** Luftfahrt-Bundesamt, Brunswick (West Germany).

## **INFORMATION FROM THE FEDERAL AVIATION OFFICE ON DEVELOPMENT, MANUFACTURING, NOISE, MODEL LICENSING, TRAFFIC LICENSING, MAINTENANCE AND SERVICING [DAS LUFTFAHRT-BUNDESAMT INFORMIERT: ENTWICKLUNG, HERSTELLUNG, L'ARM, MUSTERZULASSUNG, VERKEHRSZULASSUNG, WARTUNG UND INSTANDHALTUNG]**

1986 45 p In GERMAN

(ETN-86-98202) Avail: NTIS HC A03/MF A01

Information on aircraft and aviation is given for owners, pilots, and technicians. Model testing and licensing, parts testing and inspection, and single aircraft parts for self construction are treated. Modifications of aircraft equipment are discussed. Maintenance and small repairs are treated. The identification of aircraft, problems concerning aircraft noise, and aircraft fee systems are outlined. ESA

**N87-13402#** Bundesministerium fuer Bildung und Wissenschaft, Bonn (West Germany).

## **OVERVIEW OF THE SUPPORT OF THE AERONAUTICS RESEARCH AND TECHNOLOGY BY THE BUNDESMINISTERIUM FUER FORSCHUNG UND TECHNOLOGIE (BMFT) [UEBERSICHT UEBER DIE FOERDERUNG DER LUFTFAHRTFORSCHUNG UND -TECHNOLOGIE DURCH DAS BMFT]**

H. A. HERTICH 28 Apr. 1986 31 p In GERMAN

(ETN-86-98215) Avail: NTIS HC A03/MF A01

Technology for large passenger aircraft (aerodynamics, flight mechanics, aircraft construction and structures); general aeronautics technology; helicopter technology; propulsion techniques; air traffic technology (air traffic control, aircraft control, aeronautical electronics, avionics results of the Airbus program); aircraft manufacturing technologies; test facilities (European transonic wind tunnel, wind tunnel and model technologies, cryochannel, propulsion height test stand, test stand for components made of fiber reinforced materials, advanced technologies testing aircraft system, DO128 research aircraft); and supersonic and hypersonic technologies are reviewed. ESA

**N87-14243** British Aerospace Aircraft Group, Bristol (England). Advanced Manufacturing Research Dept.

## **FIRST INTERNATIONAL CONFERENCE MATERIALS IN AEROSPACE**

D. CHARLES, comp. 1986 16 p Conference held in London, England, 2-4 April 1986

(BAE-S85/AMR/0080; ETN-86-98152) Avail: Issuing Activity

The conference organized by the Royal Aeronautical Society is described. Keynote papers on materials and their applications were presented by speakers from leading aerospace companies and academic institutions. Opportunities were given for discussion of the topics covered by the speakers and a more general discussion was held at the close of each session. In addition to the paper presented there was a small exhibition by materials producers and processors. Some topics covered were: Surface treatment of steels; Titanium castings; Lubrication; Thermoplastic composites; Rapidly solidified aluminum alloys; Self reinforcing polymers; Carbon-carbon composites; High temperature titanium alloys; Development of super alloys; Ceramics; Developments in adhesives; Aluminum lithium alloys; Fire/smoke/toxicity; and Corrosion protection. E.R.

**N87-14244** Civil Aviation Authority, London (England).  
**RELIABILITY OF IN-SERVICE INSPECTION OF TRANSPORT AIRCRAFT STRUCTURES Final Report**  
 M. W. B. LOCK and J. E. STRUTT Aug. 1985 120 p Sponsored by United Kingdom Air Registration Board  
 (CAA-PAPER-85013; ISBN-0-86039-251-1; ETN-87-98602) Avail: Issuing Activity

The reliability of structural inspection of transport aircraft, particularly the influence of human factors on the performance of inspection was studied. Data for the study was obtained from discussions with and visits to operators; mandatory occurrence reports; a questionnaire circulated amongst aircraft operating companies; and by detailed task analysis at shop floor level. The importance of performance-shaping factors to the inspection activity is established. The results suggest that the most critical steps are defect searching and recognition, and that greater attention should be paid to primary and secondary access, lighting, and eyesight.

ESA

**N87-14246#** Fulmer Research Inst. Ltd., Stoke Poges (England).  
**AN ASSESSMENT OF AIRCRAFT REPAIR SCHEMES FOR BATTLE DAMAGE AND PERMANENT USAGE Final Report**  
 S. P. SHENTON, J. WILSON, and D. P. BASHFORD 6 Jan. 1986 63 p  
 (Contract MOD-A91A/906)  
 (R946/8; BR98808; ETN-86-98380) Avail: NTIS HC A04/MF A01

A wet laminating system for temporary fiber reinforced plastic repairs to secondary metallic structures of aircraft was established. Repairs can be implemented in-the-field, with minimum resources or prior knowledge of the materials, permitting the aircraft to be operational within 4 hr. The good short term tensile, fatigue, and environmental resistance achieved by wet laminated patches led to their consideration for repairs having a permanent status. These repairs would be cheap to implement. For such repairs more appropriate resin systems and preparation techniques are needed to provide better conditions for long-term performance. Results show that good static tensile performance can be maintained when subjected to extremes of temperature. Induced moisture absorption causes a reduction in tensile strength at elevated temperatures.

ESA

## 02

### AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A87-17025**  
**PRESSURE FLUCTUATIONS CAUSED BY TRANSONIC SHOCK/BOUNDARY-LAYER INTERACTION**

A. R. G. MUNDELL (Royal Aircraft Establishment, Aerodynamics Dept., Farnborough, England) and D. G. MABEY (Royal Aircraft Establishment, Aerodynamics Dept., Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Aug.-Sept. 1986, p. 274-282. refs

An analysis of an extensive series of unsteady and steady pressure measurements at transonic speeds on a rigid 12-percent thick NACA 16 series aerofoil reveals a useful classification of the type of excitation characteristics of particular flow regions. The pressure fluctuation measurements suggest that when the shock from the aerofoil reaches the tunnel roof, serious interference (both dynamic and static) occurs. The RAE 2 x 1.5-ft Transonic Tunnel used for the tests has low levels of flow unsteadiness at low frequencies, making it a useful facility for basic research in time-dependent aerodynamics.

Author

**A87-17587**  
**VISCOUS FLOW PAST A WING PROFILE [OBTEKANIE PROFILIA KRYLA POTOKOM VIAZKOI ZHIDKOSTI]**

I. V. ZELENOV and V. IA. SHKADOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1986, p. 29-36. In Russian. refs

Flow of an incompressible viscous fluid past a wing profile at low Reynolds numbers is investigated by solving numerically full Navier-Stokes equations. Stationary nonseparated and separated flows are determined, as are periodic regimes with the formation of a vortex street in the wake. The relationship between the Strouhal and Reynolds numbers determined from this linear dimension depends only slightly on the angle of attack and profile shape and is close to an experimentally obtained relationship for circular cylinders.

V.L.

**A87-17589**  
**AERODYNAMIC CHARACTERISTICS OF POROUS DISKS AT SUBSONIC INCOMING FLOW VELOCITIES [AERODINAMICHESKIE KHARAKTERISTIKI PRONITSAE MYKH DISKOV PRI DOZVUKOVYKH SKOROSTI AKH NABEGAIUSHCHEGO POTOKA]**

S. A. FESHCHENKO Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1986, p. 123-128. In Russian. refs

The aerodynamic characteristics of porous disks normal to the incoming flow are investigated experimentally over a wide range of perforation parameters and subsonic incoming flow velocities. It is found that the disk thickness-to-diameter ratio has a noticeable effect on the parameters of the backstreaming regions. The aerodynamic drag of the disks depends not only on the degree of permeability but also on the uniformness of the perforation. It is also found that supersonic jets are formed behind a porous disk even at subsonic incoming flow velocities.

V.L.

**A87-17590**  
**A COMPARISON BETWEEN THE INTEGRAL CHARACTERISTICS AND THE SHAPE OF THE PROFILED CONTOURS OF LAVAL NOZZLES WITH GRADUAL AND ABRUPT CONVERGENCE [SRAVNENIE INTEGRAL'NYKH KHARAKTERISTIK I FORMY PROFILIROVANNYKH KONTOUROV SOPEL LAVALIA S 'PLAVNYM' S 'VNEZAPNYM' SUZHENIAMI]**

A. N. KRAIKO, N. I. TILLIAEVA, and S. A. SHCHERBAKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1986, p. 129-137. In Russian. refs

The effect of the generatrix shape of the subsonic section on the integral characteristics and the shape of the profiled supersonic sections of plane and axisymmetric Laval nozzles is investigated. Nozzles with gradual convergence at the inlet and nozzles with abrupt convergence are compared for the same flow rates and dimensional constraints for the nozzle as a whole rather than its supersonic part only. With such a formulation, for an ideal gas, nozzles with abrupt convergence have better characteristics than nozzles with gradual convergence.

V.L.

**A87-17709**  
**SLAT WINGS [RESHETCHATYE KRYL'IA]**  
 S. M. BELOTSEKOVSKII, L. A. ODNOVOL, IU. Z. SAFIN, A. I. TIULENEV, V. P. FROLOV et al. Moscow, Izdatel'stvo Mashinostroenie, 1985, 320 p. In Russian. refs

The book presents results of theoretical and experimental studies of slat wings, i.e., wings formed by a large number of slats arranged in a Venetian blind or a honeycomb pattern between side members. In particular, attention is given to the geometrical parameters of slat wings, the aerodynamics of slat wings at subsonic, transonic, and supersonic velocities, and general characteristics of slat wings related to their aerodynamics as well as weight and structural characteristics.

V.L.



**A87-17747**

**APPLICATION OF AN IMPLICIT ITERATION DIFFERENCE SCHEME TO THE SOLUTION OF NONSTATIONARY NAVIER-STOKES EQUATIONS [PRIMENENIE ODNOI NEIAVNOI ITERATSIONNOI RAZNOSTNOI SKHEMY K RESHENIIU NESTATSIONARNYKH URAVNIENII NAV'E-STOKSA]**

V. M. PASKONOV, T. P. PETUKHOVA, and S. V. RUSAKOV IN: Computational mathematics and mathematical computer software . Moscow, Izdatel'stvo Moskovskogo Universiteta, 1985, p. 216-231. In Russian. refs

An implicit iteration difference scheme is proposed for solving nonstationary Navier-Stokes equations for a viscous compressible gas. The scheme, which is of second-order accuracy with respect to space and time, is demonstrated by using it to model nonstationary axisymmetric flow in the near wake produced by ring injection from the rear of a body moving at a supersonic velocity ( $M = 3$ ,  $Re = 200$ ). V.L.

**A87-17748**

**USING SIMPLIFIED NAVIER-STOKES EQUATIONS FOR CALCULATING FLOW OF A VISCOUS GAS PAST LONG BODIES [PRIMENENIE UPROSHCHENNYKH URAVNIENII NAV'E-STOKSA K RASCHETU OBTEKANIYA DLINNYKH TEL VIAZKIM GAZOM]**

O. N. BELOVA, N. S. KOKOSHINSKAIA, and V. M. PASKONOV IN: Computational mathematics and mathematical computer software . Moscow, Izdatel'stvo Moskovskogo Universiteta, 1985, p. 231-239. In Russian. refs

Supersonic flows of a viscous gas past long bodies are investigated for moderately high Reynolds numbers using simplified Navier-Stokes equations. The numerical integration of the equations is carried out using a marching scheme; flow past spherically blunted cylinder and cone is analyzed. The effect of the Reynolds number and body shape on the flow field, friction resistance coefficient, and heat flow is discussed. V.L.

**A87-17749**

**A MODULAR APPROACH TO THE SOLUTION OF A CLASS OF PROBLEMS IN INTERNAL GAS DYNAMICS [MODUL'NYI PODKHOD K RESHENIIU ODNOGO KLASSA ZADACH VNUTRENNEI GAZOVOI DINAMIKI]**

G. S. ROSLIAKOV and M. V. SHUSTOVA IN: Computational mathematics and mathematical computer software . Moscow, Izdatel'stvo Moskovskogo Universiteta, 1985, p. 239-249. In Russian. refs

A class of gasdynamic problems is examined which involves calculating gas flows in nozzles and jets. A modular analysis of algorithms based on the method of characteristics is presented, and a set of computer programs is developed and implemented. The software makes it possible to calculate a large variety of problems by using a relatively small set of modules and elementary problems. V.L.

**A87-17811#**

**UNSTEADY LOADING ON AIRFOIL DUE TO VORTICES RELEASED INTERMITTENTLY FROM ITS SURFACE**

C.-Y. CHOW (Colorado, University, Boulder) and C.-S. CHIU Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 750-755. refs

(Contract AF-AFOSR-81-0037)

An unsteady flow analysis is made of the flow past a symmetric airfoil with identical vortices released intermittently from its upper surface. The vortex train is used to simulate the flow observed in the laboratory, which was perturbed by an oscillating spoiler or a rotating cam embedded in the airfoil surface. Based on numerical computations, the airfoil lift generally increases oscillationally with time and seems to approach an asymptotic value as time increases indefinitely. The asymptotic lift is enhanced with increasing frequency and is only slightly influenced by changing the vortex-releasing position along the chord. The behavior of the drag is similar to that of the lift, but its magnitude is two orders smaller. The study also indicates that it is more efficient to

implement the vortex-augmented unsteady lift at higher angles of attack of the airfoil. Author

**A87-17814#**

**AERODYNAMIC TRADEOFF STUDY OF CONVENTIONAL, CANARD, AND TRISURFACE AIRCRAFT SYSTEMS**

B. P. SELBERG and K. ROKHSAZ (Missouri-Rolla, University, Rolla) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 768-774. Previously cited in issue 01, p. 4, Accession no. A86-11037. refs

**A87-17815#**

**METHOD FOR DESIGNING CLOSED AIRFOILS FOR ARBITRARY SUPERCRITICAL SPEED DISTRIBUTIONS**

G. VOLPE and R. E. MELNIK (Grumman Corporate Research Center, Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 775-782. refs

(AIAA PAPER 85-5023)  
A method for designing airfoil profiles of specified trailing-edge thickness corresponding to given arbitrary supersonic speed distributions is described in this paper. It is known that the surface speed must satisfy three constraints in order for a solution to exist. Hence, to guarantee satisfaction of the constraints in the method, the speed distribution is specified with three free parameters whose values are found automatically. The modifications introduced to an ideal target speed distribution are everywhere smooth and avoid the occasional 'spikes' that were present in an earlier version of the method. The new functional forms used to modify the ideal target are well behaved at all times and prevent undue excursions of the airfoil profile during the iteration process. As a result, the iteration is much faster than in the earlier version of the method and it is now possible to quickly design airfoil shapes that are shockless or have shocks on the surface or off in the field. Author

**A87-17816\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AERODYNAMIC DESIGN CONSIDERATIONS FOR EFFICIENT HIGH-LIFT SUPERSONIC WINGS**

D. S. MILLER and R. M. WOOD (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 783-788. Previously cited in issue 01, p. 5, Accession no. A86-11041. refs

**A87-17817\*#** North Carolina State Univ., Raleigh.

**EXPERIMENTAL INVESTIGATION OF APEX FENCE FLAPS ON DELTA WINGS**

R. J. VESS (North Carolina State University, Raleigh), R. A. WAHLS, and C. A. MOSKOVITZ Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 789-797. Previously cited in issue 01, p. 4, Accession no. A86-11027. refs

(Contract NCC1-46)

**A87-17818\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMMENT ON 'CONVERGENCE CHARACTERISTICS OF A VORTEX-LATTICE METHOD FOR NONLINEAR CONFIGURATION AERODYNAMICS'**

J. M. LUCKRING (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 798, 799; Author's Reply, p. 799, 800. refs

It is proposed that the study of Rusak et al. (1985), which reports numerical modeling sensitivities on longitudinal force/moment properties for a vortex-lattice method incorporating free vortex filaments to represent the leading-edge vortex separation, employs a formula that is strongly affected by the particular points of analysis chosen. This results in a narrowly applicable curve fit, where numerical sensitivities of the theory are inappropriately traded off against physical effects that are not modeled in that theory. Attention is also given to questionable drag estimate computations. O.C.

A87-17883#

**THE AERODYNAMIC DESIGN OF OBLIQUE WING AIRCRAFT**

I. KROO (Stanford University, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 18 p. refs

(AIAA PAPER 86-2624)

This paper deals with the potential advantages of asymmetrically-swept (oblique-wing) aircraft, the difficulties encountered in their design, and some of the methods employed in the development of a supersonic research aircraft with an oblique wing. A variety of computational tools were combined with wind tunnel and water tunnel results in the aerodynamic design of a highly-swept oblique wing. A rapid-turnaround performance-prediction method was developed for initial sizing, optimal sweep scheduling, and selection of design flight conditions. The paper focuses on those aspects of the design and analysis methods of particular importance to oblique wings. Author

A87-17884#

**ALL LAMINAR SUPERCRITICAL LFC AIRFOILS WITH NATURAL LAMINAR FLOW IN THE REGION OF THE MAIN WING STRUCTURE**

W. PFENNINGER, C. S. VEMURU (Analytical Services and Materials, Inc., Hampton, VA), G. VOLPE (Grumman Aerospace Corp., Bethpage, NY), and J. VIKEN AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 46 p. refs

(AIAA PAPER 86-2625)

Study results are presented for supercritical laminar flow control airfoils with undercut front and aft lower surfaces and flat pressure distributions over the upper surface. Relatively sharp leading edges and cancellation of the boundary layer crossflow of the leading edge by an opposite crossflow in the pressure rise area downstream of the front pressure minimum is noted to virtually eliminate crossflow instability in the upper 'rooftop' surface area of swept wings employing airfoil profiles of the present type. O.C.

A87-17886#

**WAVE DRAG ANALYSIS OF REALISTIC FIGHTER AIRCRAFT USING A FULL POTENTIAL METHOD**

K. B. WALKLEY and G. E. SMITH (DEI-Tech, Inc., New Port News, VA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. USAF-supported research. refs

(AIAA PAPER 86-2627)

Wave drag coefficients for several realistic fighter configurations have been computed using a full potential method and compared with the results of parallel far-field (area rule) analyses and experimental zero-lift drag data. Configurations analyzed included a supersonic cruise wing-body, an advanced fighter concept, and the F-16 aircraft. The results of these studies indicate that the full potential method generally gives wave drag levels which more closely agree with test data than do the far-field values. The full potential method does not encounter problems when components such as wing or tail leading edges or canopy forward faces are at sonic conditions as does the far-field techniques. Some problems were encountered in applying the full potential method such as generating computational grids in deeply recessed areas near diverters. Author

A87-17887#

**NAVIER-STOKES SIMULATION FOR FLOW PAST AN OPEN CAVITY**

D. OM (Boeing Commercial Airplane Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. Research supported by the Boeing Commercial Airplane Co. refs

(AIAA PAPER 86-2628)

A two-dimensional Navier-Stokes code was developed to simulate the flow past an open cavity. The code employs the split explicit predictor-corrector algorithm of MacCormack in conservation-law form. The purpose was to examine the unsteadiness of the shear layer and obtain details of the flowfield.

Cavity flow was simulated for two different cavity sizes as well as for two different ramp shapes. Comparison with wind tunnel experiment shows good agreement. Computations also showed that the shear layer stability depends very strongly on the shape of the aft ramp. These conclusions were very useful in designing the cavity shape for the B767-AOA. Author

A87-17902#

**THE APPLICATION OF COMPUTATIONAL FLUID DYNAMICS TO AIRCRAFT DESIGN**

R. J. BUSCH, JR., M. JAGER, and B. BERGMAN (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 20 p. refs

(AIAA PAPER 86-2651)

The application of computational fluid dynamics within the aircraft design process is demonstrated. The paper focuses on the use of an Euler code for the analysis and design of aircraft subsystems as well as complete aircraft. Calculations of internal and external flows are described, and computed results are compared with test data where possible. A three dimensional inverse wing design method is demonstrated. Author

A87-17907#

**INLET ANALYSIS USING COMPUTATIONAL FLUID DYNAMICS**

L. G. HUNTER and T. J. KENT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. refs

(AIAA PAPER 86-2661)

Numerical solutions of the 2-D/axisymmetric unsteady compressible implicit full Navier-Stokes equations were obtained for the inlet flowfield of a mixed compression spike inlet at Mach 2.6 and two hypersonic inlets at Mach 7.4. The computational results were able to predict centerbody and cowl static pressures, as well as some limited throat Mach number data. The code is fully vectorized in the streamwise direction which is an advantage for long and thin hypersonic inlets. Typical convergence times are approximately five minutes for grids of 200 x 60 points. The efficiency and simplicity of this code allows it to be used for design purposes. Author

A87-17932#

**COMPARISON OF VORTEX LATTICE AND PRANDTL-MUNK RESULTS FOR OPTIMIZED THREE-SURFACE AIRCRAFT**

K. ROKHSAZ and B. P. SELBERG (Missouri-Rolla, University, Rolla) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. refs

(AIAA PAPER 86-2695)

The results of Prandtl-Munk theory for prediction of the induced drag of three-surface general aviation aircraft have been examined and compared with vortex lattice results. Substantial differences between the two predictions have been shown in the presence of practical non-elliptic spanwise load distributions. At the same time, a parametric study has been carried out to determine the sensitivity of lift to induced drag ratio to different design variables. Using the resulting trends, a three-surface general aviation aircraft has been modeled and compared with its equivalent canard and conventional configurations. It has been demonstrated that while the three-surface geometry is more efficient than a canard configuration, it remains inferior to a conventional design. Author

A87-18539

**AN ACTUATOR DISC ANALYSIS OF UNSTEADY SUBSONIC CASCADE FLOW**

D. S. WHITEHEAD (Cambridge, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 109, Sept. 8, 1986, p. 207-213. refs

A rather simple analytical result is derived for the aerodynamic forces acting on a cascade of unloaded flat plates vibrating in subsonic flow. The principal assumptions are that the frequency and the inter-blade phase angle are both small. This enables the flow through the blades to be treated as quasi-steady, and the

## 02 AERODYNAMICS

Prandtl-Glauert transformation is used to allow for the effect of compressibility. The blade force is zero near the resonance or cut-off points, with wild behavior near these points. Bending vibration is always found to be damped, but flutter in pure torsion is always predicted. Author

### A87-18576#

#### AN ANTIDIFFUSIVE NUMERICAL METHOD SOLVING SUPERSONIC THREE DIMENSIONAL VISCOUS SEPARATED FLOWS

H. ZHANG, Z. YU, L. LU, and M. ZHENG (China Aerodynamic Research and Development Centre, Mianyang, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, Sept. 1986, p. 251-257. In Chinese, with abstract in English.

### A87-18577#

#### CVR METHOD FOR IDENTIFICATION OF NONSTEADY AERODYNAMIC MODEL

J. XIE (Tongji University, Shanghai, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, Sept. 1986, p. 258-268. In Chinese, with abstract in English. refs

A new method, which uses the coupled vibration record (CVR) of a very simple section model as basic information to identify a two-dimensional nonsteady aerodynamic model for nonstreamlined bodies, is proposed. With the CVR method, the system eigenmatrices are first identified to get the system complex modes at various wind speeds using the Kalman filtering technique, and then the nonsteady aerodynamic model is obtained by applying the Laplace transform to the dynamic equilibrium equation. In comparison with the current Scanlan method, the CVR method not only greatly reduces the technical requirement and test work on wind tunnel tests, but also markedly increases the accuracy of the results. Author

### A87-18579#

#### ITERATIVE COMPUTATION OF TRANSONIC POTENTIAL FLOW PAST AEROFOILS WITH BOUNDARY LAYER

P. LIU, S. LUO, and Q. E (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, Sept. 1986, p. 279-288. In Chinese, with abstract in English. refs

Outer inviscid flow about airfoils is computed by the transonic small perturbation (TSP) equation and the improved TSP equation using the Murman-Cole conservative scheme, a nonconservative scheme, and the Engquist-Osher Scheme. The results show that their stability, convergence, and converged solutions are similar except the shock wave position. Linear stability of the SLOR method with artificial-time-damp is discussed. The accuracy of differential computation can be improved largely by using a second-order scheme. Finally, an inviscid-viscous iterative method is applied to NACA 0012 airfoil and a 6 percent thickness circular arc airfoil. Author

### A87-18584#

#### IMPROVEMENTS ON SUPERSONIC KERNEL FUNCTION METHOD AND ITS APPLICATION TO FLUTTER CALCULATION

S. LU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 4, Sept. 1986, p. 333-337. In Chinese, with abstract in English. refs

Some improvements are made in the spanwise integration of the supersonic kernel function method. The results of the flutter calculation of two delta wings show that the accuracies of the flutter velocity and frequency are improved considerably compared with those obtained using the original method. Author

### A87-18926#

#### AERODYNAMICS OF TWO-DIMENSIONAL BLADE-VORTEX INTERACTION

G. R. SRINIVASAN, W. J. MCCROSKEY (JAI Associates, Inc., Mountain View, CA), and J. D. BAEDER (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Oct. 1986, p. 1569-1576. Previously cited in issue 19, p. 2737, Accession no. A85-40685. refs (Contract DAAG29-85-C-0002)

A87-18927\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

#### ACTIVE TRANSITION FIXING AND CONTROL OF THE BOUNDARY LAYER IN AIR

L. MAESTRELLO (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, Oct. 1986, p. 1577-1581. Previously cited in issue 10, p. 1392, Accession no. A85-25950. refs

### A87-18944#

#### SECOND-ORDER THICKNESS TERMS IN UNSTEADY WING THEORY

W. GU (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China) AIAA Journal (ISSN 0001-1452), vol. 24, Oct. 1986, p. 1702, 1703.

Attention is given to questions concerning which of the unsteady flow terms arising in the calculation of second-order theory on a three-dimensional body should be retained. It is noted that, in general, the second-order approximation will not be uniformly valid in the neighborhood of the wing edges and the Mach cone emanating from the vortex of the gap. O.C.

### A87-18955#

#### APPLICATION OF DIVERGING MOTIONS TO CALCULATE LOADS FOR OSCILLATING MOTIONS

M. H. L. HOUNJET (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) AIAA Journal (ISSN 0001-1452), vol. 24, Oct. 1986, p. 1723-1725.

The growing use of active control technology has led to the development of calculation methods that yield nonharmonic motion results, as well as of a technique yielding similar results through the analytic continuation of a polynomial fit through aerodynamic loads for purely harmonic motions. In order to reduce the computation costs associated with complex configurations and flows, an alternative procedure has been developed which allows aeroelasticians to reduce computational costs by a factor of four. O.C.

### A87-19223

#### NOTAR (NO TAIL ROTOR) HOVER TESTING USING A SCALE MODEL IN WATER

J. R. VAN HORN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings, Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 231-241. refs

Attention is given to test methodologies and test results pertaining to the flow interaction at the circulation control tail boom/aft fuselage juncture of a geometrically scaled wind tunnel model of the 'NOTAR' (No Tail Rotor) demonstrator. A simple solution to the perceived requirement of flow control fences was found as a result of these flow visualization efforts which requires no additional power. The use of a flow visualization water tank for helicopter rotor-related flowfield studies has been validated; it is found to furnish a superior basis for accurate LDV measurements, since the seed particles can be larger than in air to yield commensurately higher SNRs. O.C.

**A87-19224**

**A GENERALISED MODEL FOR AIRFOIL UNSTEADY AERODYNAMIC BEHAVIOUR AND DYNAMIC STALL USING THE INDICIAL METHOD**

J. G. LEISHMAN and T. S. BEDDOES (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 243-265. Research supported by the Ministry of Defence (Procurement Executive). refs

The indicial formulation is proposed for use in helicopter rotor airload calculation as it is a versatile and computationally efficient method. The formulation of generalized indicial aerodynamic lift and pitching moment functions is discussed and their application is validated both theoretically and experimentally. The modeling is subsequently extended to nonlinear regimes involving partially and fully separated flows. Model validation is achieved with experimental two-dimensional unsteady test data for the NACA 0012 airfoil in the ramp and oscillatory pitch modes. K.K.

**A87-19225\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ROTOR/WING AERODYNAMIC INTERACTIONS IN HOVER**

F. F. FELKER and J. S. LIGHT (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 279-302. Previously announced in STAR as N86-28060. refs

An experimental and theoretical investigation of rotor/wing aerodynamic interactions in hover is described. The experimental investigation consisted of both a large-scale and small-scale test. A 0.658-scale, V-22 rotor and wing was used in the large-scale test. Wind download, wing surface pressure, rotor performance, and rotor downwash data from the large-scale test are presented. A small-scale experiment was conducted to determine how changes in the rotor/wing geometry affected the aerodynamic interactions. These geometry variations included the distance between the rotor and wing, wing incidence angle, and configurations both with the rotor axis at the tip of the wing (tilt rotor configuration) and with the rotor axis at the center of the wing (compound helicopter configuration). A wing with boundary-layer control was also tested to evaluate the effect of leading and trailing edge upper surface blowing on the wing download. A computationally efficient, semi-empirical theory was developed to predict the download on the wing. Finally, correlations between the theoretical predictions and test data are presented. Author

**A87-19226**

**ANALYSIS OF V-22 TILT-ROTOR AIRCRAFT USING PANEL METHODS**

G. J. CARLIN, JR., W. E. STAEDLI, and R. M. HODGES, JR. (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 303-314. refs

The present investigation assesses the ability of two production panel method computer codes, PAN-AIR and VSAERO, to analyze the configuration of the V-22 tilt-rotor aircraft. Two simple wings are modeled for code verification, and a computer time study is carried out. V-22 airfoil, wing-body, and complete configurations are then analyzed. It is concluded that both codes can adequately predict lift coefficients and trends in pitching moment. K.K.

**A87-19246\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ACOUSTIC PROPAGATION USING COMPUTATIONAL FLUID DYNAMICS**

J. D. BAEDER, W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA), and G. R. SRINIVASAN (JAI Associates, Inc., Mountain View, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 551-562. refs

The propagation characteristics of several helicopter airfoil profiles have been investigated using the transonic small disturbance equation. A test case was performed to generate a moving shock that propagated off the airfoil. Various grids were then examined to determine their ability to accurately capture these propagating shock waves. Finally, the case of airfoil-vortex interactions was thoroughly studied over a wide range of Mach numbers and airfoil shapes with particular emphasis on the transonic regime; this results in a highly complicated fluctuation of lift, drag, and pitching moment. The calculated acoustic intensity levels, along with the details of the computational flow field, provide new insights into the understanding of transonic airfoil-vortex interactions. Author

**A87-19259\*** California Univ., Los Angeles.

**ARBITRARY MOTION UNSTEADY AERODYNAMICS AND ITS APPLICATION TO ROTARY-WING AEROELASTICITY**

P. P. FRIEDMANN (California, University, Los Angeles) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 757-776. refs (Contract NAG2-209)

This paper presents in a unified manner recent research on arbitrary motion unsteady aerodynamics with an emphasis on applications to a number of rotary wing aeroelastic problems. The term arbitrary motion is used to denote growing or decaying oscillations with a certain frequency. The specific topics treated in this paper are: (1) generalization of Greenberg's theory and its application to hingeless rotor aeroelastic stability; (2) description of a new technique for formulating finite state approximations to steady aerodynamic theories, which are suitable for both fixed-wing and rotary-wing applications, and its application to generalize Loewy's theory; (3) comparison of fixed wing and rotary-wing indicial response functions; (4) influence of arbitrary motion aerodynamics, as represented by dynamic inflow on a helicopter in ground resonance. From the discussion of these topics a number of useful conclusions on the fundamental nature of arbitrary motion aerodynamics and its role in rotary-wing aeroelasticity are obtained. Author

**A87-19275\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A REVIEW OF CURRENT FINITE DIFFERENCE ROTOR FLOW METHODS**

F. X. CARADONNA and C. TUNG (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 967-983. refs

Rotary-wing computational fluid dynamics is reaching a point where many three-dimensional, unsteady, finite-difference codes are becoming available. This paper gives a brief review of five such codes, which treat the small disturbance, conservative and nonconservative full-potential, and Euler flow models. A discussion of the methods of applying these codes to the rotor environment (including wake and trim considerations) is followed by a comparison with various available data. These data include tests of advancing lifting and nonlifting, and hovering model rotors with significant supercritical flow regions. The codes are also compared for computational efficiency. Author

**A87-19276\*** Georgia Inst. of Tech., Atlanta.

### **EULER CALCULATIONS FOR ROTOR CONFIGURATIONS IN UNSTEADY FORWARD FLIGHT**

L. N. SANKAR (Georgia Institute of Technology, Atlanta) and C. TUNG (NASA, Ames Research Center; U.S. Army Aeroflightdynamics Directorate, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 985-995. Army-supported research. refs

A solution procedure is presented for the lifting transonic flow past modern rotor configurations in forward flight. In this procedure, the three-dimensional, unsteady Euler equations are solved in strong conservation form on a body-fitted moving coordinate system. A hybrid procedure of second order spatial accuracy and first order temporal accuracy is used to integrate the governing equations. In lifting flows, the effect of the elements of wake not captured by the computational procedure, and other aeroelastic effects are accounted for as local angle of attack corrections. Detailed comparisons with experimental data are presented for a 1/7 scale model of the Cobra OLS rotor, and for a three-bladed rotor tested in France. Some preliminary results are also presented for a three-dimensional blade vortex interaction problem. Author

**A87-19277\*** United Technologies Research Center, East Hartford, Conn.

### **A FULL POTENTIAL ROTOR ANALYSIS WITH WAKE INFLUENCE USING AN INNER-OUTER DOMAIN TECHNIQUE**

T. A. EGOLF and S. P. SPARKS (United Technologies Research Center, East Hartford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 997-1011. refs  
(Contract NAS2-11150)

A three-dimensional, quasi-steady, full potential flow solver was adapted to include realistic rotor wake influence for the aerodynamic analysis of helicopter rotors. The method uses an inner/outer domain technique to accommodate wake effects. Nonlinear flow is computed in the inner domain using a finite difference solution method. The wake is modeled using prescribed wake techniques to allow for the inclusion of realistic wake geometries. Portions of the wake passing inside the inner domain are treated using an embedded vortex technique. The procedure couples the wake influence with the inner domain solution in a consistent and efficient solution process. Correlation with measured lifting transonic data in hover and forward flight is shown which demonstrates the merits of the approach. Author

**A87-19278**

### **DYNAMIC STALL OF OSCILLATING AIRFOILS**

J. C. WU, C. M. WANG, J.-C. WU, and L. N. SANKAR (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1013-1024. Research supported by the McDonnell Douglas Helicopter Co. and U.S. Army. refs

Two solution procedures are discussed for computing the dynamic stall characteristics of arbitrary shaped geometries. In the first procedure, the incompressible viscous flow equations are solved using an efficient zonal approach. The zonal approach allows the flow region to be separated into boundary layer, separated flow and potential flow regions, and solves the appropriate equations only in the vortical region. In the second approach, the compressible Navier-Stokes equations are solved on a rotating, body-fitted coordinate system. A number of incompressible and compressible flow results are presented for the light and deep dynamic stall problems, and compared with available experimental data. Author

**A87-19292#**

### **CALCULATION FORMULAE FOR LIFT AND MOMENT COEFFICIENTS FOR OSCILLATING ARBITRARY AIRFOILS IN SUPERSONIC FLOW**

L. DRAGOS (Bucuresti, Universitatea, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 31, July-Aug. 1986, p. 345-352. refs

Using the fundamental solution method developed by Dragos (1984 and 1985), a general theory of supersonic motion past thin oscillating airfoils is given. The integral equation is obtained for the jump of the pressure. By means of the solution to this equation explicit calculation formulas for the lift and moment coefficients are deduced. Author

**N87-13403\*#** National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

### **WATER FACILITIES IN RETROSPECT AND PROSPECT: AN ILLUMINATING TOOL FOR VEHICLE DESIGN**

G. E. ERICKSON, D. J. PEAK, J. DELFRATE, A. M. SKOW, and G. N. MALCOLM Nov. 1986 31 p  
(NASA-TM-89409; A-87021; NAS 1.15:89409) Avail: NTIS HC A03/MF A01 CSCL 01A

Water facilities play a fundamental role in the design of air, ground, and marine vehicles by providing a qualitative, and sometimes quantitative, description of complex flow phenomena. Water tunnels, channels, and tow tanks used as flow-diagnostic tools have experienced a renaissance in recent years in response to the increased complexity of designs suitable for advanced technology vehicles. These vehicles are frequently characterized by large regions of steady and unsteady three-dimensional flow separation and ensuing vortical flows. The visualization and interpretation of the complicated fluid motions about isolated vehicle components and complete configurations in a time and cost effective manner in hydrodynamic test facilities is a key element in the development of flow control concepts, and, hence, improved vehicle designs. A historical perspective of the role of water facilities in the vehicle design process is presented. The application of water facilities to specific aerodynamic and hydrodynamic flow problems is discussed, and the strengths and limitations of these important experimental tools are emphasized. Author

**N87-13404\*#** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

### **LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A GENERIC FIGHTER MODEL WITH A WING DESIGNED FOR SUSTAINED TRANSONIC MANEUVER CONDITIONS**

J. C. FERRIS Dec. 1986 89 p  
(NASA-TM-87729; L-15774; NAS 1.15:87729) Avail: NTIS HC A05/MF A01 CSCL 01A

A wind-tunnel investigation was made to determine the longitudinal aerodynamic characteristics of a fixed-wing generic fighter model with a wing designed for sustained transonic maneuver conditions. The airfoil sections on the wing were designed with a two-dimensional nonlinear computer code, and the root and tip section were modified with a three-dimensional code. The wing geometric characteristics were as follows: a leading-edge sweep of 45 degrees, a taper ratio of 0.2141, an aspect ratio of 3.30, and a thickness ratio of 0.044. The model was investigated at Mach numbers from 0.600 to 1.200, at Reynolds numbers, based on the model reference length, from 2,560,000 to 3,970,000, and through a model angle-of-attack range from -5 to +18 degrees. Author

**N87-13405\*** Scientific Research Associates, Inc., Glastonbury, Conn.  
**COMPUTATION OF MULTI-DIMENSIONAL VISCOUS SUPERSONIC JET FLOW** Final Contractor Report  
 Y. N. KIM, R. C. BUGGELN, and H. MCDONALD Washington  
 NASA Oct. 1986 128 p  
 (Contract NAS3-22759)  
 (NASA-CR-4020; E-3210; NAS 1.26:4020) Avail: NTIS HC A07/MF A01 CSCL 01A

A new method has been developed for two- and three-dimensional computations of viscous supersonic flows with embedded subsonic regions adjacent to solid boundaries. The approach employs a reduced form of the Navier-Stokes equations which allows solution as an initial-boundary value problem in space, using an efficient noniterative forward marching algorithm. Numerical instability associated with forward marching algorithms for flows with embedded subsonic regions is avoided by approximation of the reduced form of the Navier-Stokes equations in the subsonic regions of the boundary layers. Supersonic and subsonic portions of the flow field are simultaneously calculated by a consistently split linearized block implicit computational algorithm. The results of computations for a series of test cases relevant to internal supersonic flow is presented and compared with data. Comparison between data and computation are in general excellent thus indicating that the computational technique has great promise as a tool for calculating supersonic flow with embedded subsonic regions. Finally, a User's Manual is presented for the computer code used to perform the calculations. Author

**N87-13407\*** British Aerospace Aircraft Group, Preston (England). Military Aircraft Div.  
**MEASUREMENT OF FORCES, MOMENTS AND PRESSURES**  
 A. R. WHITAKER 1986 86 p Presented at Wind Tunnel Lecture Series, Warton, England, Mar. 1986  
 (BAE-ARG-217; ETN-86-98382) Avail: NTIS HC A05/MF A01

Measurement of velocity and pressure in a wind tunnel is described. Strain gages, calibration, wind tunnel balances, pressure transducers, angular/linear transducers, thermocouples, and data acquisition are covered. ESA

**N87-13409\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
**VORTEX BREAKDOWN AND CONTROL EXPERIMENTS IN THE AMES-DRYDEN WATER TUNNEL**  
 F. K. OWEN and D. J. PEAKE Nov. 1986 13 p  
 (NASA-TM-89410; A-87030; NAS 1.15:89410) Avail: NTIS HC A02/MF A01 CSCL 51A

Flow-field measurements have been made to determine the effects of core blowing on vortex breakdown and control. The results of these proof-of-concept experiments clearly demonstrate the usefulness of water tunnels as test platforms for advanced flow-field simulation and measurement. Author

**N87-13411\*** Naval Surface Weapons Center, Silver Spring, Md.  
**NOTES ON A GENERIC PARACHUTE OPENING FORCE ANALYSIS** Final Report  
 W. P. LUDTKE 1 Mar. 1986 84 p  
 (AD-A170962; NSWC/TR-86-142) Avail: NTIS HC A05/MF A01 CSCL 01C

The determination of parachute opening shock forces is one of the most vital elements in decelerator system design. This report develops a generic opening shock analysis that permits calculation of velocity profiles, shock factors, maximum shock forces and their time of occurrence during deployment for many types of parachutes. Criteria are presented and methods of calculation developed. Application of the analysis to an apparent anomaly in solid cloth parachute finite mass deployment, verifies the parachute diameter effect shown in the test performance. This is illustrated by an example. Author (GRA)

**N87-13412\*** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.

**MORE RECENT RESEARCH RESULTS OF THE DFVLR IN THE DOMAIN OF AERODYNAMICS AND FLIGHT MECHANICS [NEUERE FORSCHUNGSERGEBNISSE DER DFVLR IM RAHMEN DER AERODYNAMIK UND FLUGMECHANIK]**

H. KOERNER and K. WILHELM 1986 66 p In GERMAN  
 Presented at the 4th BMFT Statusseminar Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, 28-30 April 1986  
 (ETN-86-98216) Avail: NTIS HC A04/MF A01

Aerodynamics simulation and measuring techniques (three-component laser Doppler anemometer for large wind tunnels, hot film technique for the development of the direction and magnitude of wall shear stress, IR technique for the determination of the laminar-turbulent transition, flexible adaptive test sections); aerodynamical problems (classification of separated flows, shock-boundary interaction, drag reduction by groove structures, stability and transition of laminar boundary layers); numerical aerodynamics (geometry and grid generation, solution of the Euler and Navier-Stokes equations); and configurational aerodynamics (transonic airfoil, laminar airfoil) are discussed. Active gust load reduction systems, and flight characteristics evaluation by in-flight simulation (reduced static lateral stability, utilization of direct lift control for transport aircraft) are considered. ESA

**N87-13413\*** Grenoble-1 Univ. (France). Inst. de Mecanique.  
**CAVITATION RESEARCH. CAVITATION DEVELOPED AND BOUNDARY LAYERS FOR THE NACA 16-012 PROFILE WITH OSCILLATING INCIDENCE (STRESS MEASUREMENTS) [RECHERCHES EN CAVITATION. CAVITATION DEVELOPEE ET COUCHE LIMITE SUR PROFIL NACA 16-012 OSCILLANT EN INCIDENCE (MESURES D'EFFORTS)]**  
 J. P. FRANC and J. M. MICHEL Sep. 1985 51 p In FRENCH  
 (Contract DRET-81-513)  
 (ETN-86-98435) Avail: NTIS HC A04/MF A01

Airfoil stress measurements were carried out in a wind tunnel at frequencies up to 10 Hz to avoid interference with the balance drag resonant frequencies. The study follows a flow visualization analysis of the cavitation and boundary layer developed in oscillant incidence condition. The results are presented as cycles describing the lift and drag coefficients and the moments as a function of the incidence for different oscillation conditions. The observations with and without cavitation are analyzed separately. It is shown that the dynamic effects increase with the oscillation frequency and diminish when a cavity exists through a whole oscillation cycle. ESA

**N87-13414\*** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**CORRECTION FOR WALL-INTERFERENCE BY MEANS OF A MEASURED BOUNDARY CONDITION METHOD**

T. E. LABRUJERE 21 Nov. 1984 44 p  
 (NLR-TR-84114-U; B8671294; ETN-86-98650) Avail: NTIS HC A03/MF A01

A method for the determination of global corrections for wall interference in solid and ventilated wall wind tunnels (two and three dimensional) is described. The method assumes that the flow velocity is known at a control surface surrounding the model and that the main part of the flow field may be considered irrotational and subsonic. Applicability is illustrated by numerical test cases. ESA

**N87-13415\*** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**TWO-DIMENSIONAL WALL INTERFERENCE ASSESSMENT USING CALSPAN PIPES**

J. SMITH Apr. 1985 62 p  
 (NLR-TR-85065-U; B8671296; ETN-86-98653) Avail: NTIS HC A04/MF A01

The applicability of a multi velocity component static pipe for measuring boundary velocity vector distributions in wall interference assessment was explored in two-dimensional flow. Comparisons

with alternative methods to derive the local flow angle from measured pipe pressures, and analyses of associated wall corrections for a solid and slotted-wall test section show that this pipe is potentially very useful. The arrangement of the pressure measurement technique should be improved, however. ESA

**N87-13416#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

**HOW TO MAKE YOUR AERODYNAMICS IN FLUTTER CALCULATIONS CHEAPER**

M. H. L. HOUNJET 7 Aug. 1985 11 p Submitted for publication (NLR-MP-85056-U; B8668294; ETN-86-98659) Avail: NTIS HC A02/MF A01

A method for the cost effective calculation of unsteady aerodynamic loads due to harmonic oscillating motions is described. The method obtains the unsteady aerodynamic loads from a polynomial in which the coefficients are determined by fitting through aerodynamic loads obtained for exponentially diverging motions. The method was applied to an oscillating rectangular low aspect ratio wing. ESA

**N87-13418#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France).

**UNSTEADY TRANSONIC FLOW COMPUTATIONS FOR AGARD TWO-DIMENSIONAL AND THREE-DIMENSIONAL AEROELASTIC CONFIGURATIONS**

J. J. ANGELINI, P. GIROUDROUX-LAVIGNE, J. P. GRISVAL, J. C. LEBALLEUR, P. MULAK, and J. SIDES 1985 161 p In FRENCH; ENGLISH summary (ONERA-NT-1985-5; ISSN-0078-3781; ETN-86-98539) Avail: NTIS HC A08/MF A01

Numerical results on aeroelastic standard configurations are presented. The methods used for two dimensional configurations include the transonic small perturbations approach for inviscid flow, coupling methods for unseparated turbulent boundary layer, coupling methods for unseparated and separated laminar and turbulent boundary layers, and a numerical solution of the Euler equations for inviscid flow. The three dimensional configurations are studied by the transonic small disturbance approach. The detailed results are given. ESA

**N87-14247#** National Aerospace Lab., Tokyo (Japan).

**PROCEEDINGS OF THE 3RD NAL SYMPOSIUM ON AIRCRAFT COMPUTATIONAL AERODYNAMICS Special Publication of the National Aerospace Lab.**

Nov. 1985 266 p Symposium held in Tokyo, Japan, 13-14 Jun. 1985

(NAL-SP-5; ISSN-0289-260X) Avail: NTIS HC A12/MF A01

Topics addressed include: computational fluid dynamics, aerodynamic characteristics, wing and airfoil design, wake structure, numerical grid generation, wind tunnel tests, Navier-Stokes equations, laminar flow control, boundary condition effects, flow simulation, nozzle geometry, supercomputers, and aircraft icing.

**N87-14262#** National Aerospace Lab., Tokyo (Japan).

**SOME NUMERICAL CALCULATIONS BY USING LINEAR CLASSICAL SONIC THEORIES APPROACHED FROM SUB- OR SUPERSONIC SPEEDS**

Y. YAMAMOTO and S. ANDO In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 121-129 Nov. 1985 In JAPANESE; ENGLISH summary Avail: NTIS HC A12/MF A01

Unsteady aerodynamics of a two-dimensional wing at sonic speed are studied by using so-called classical sonic theories (linear), approached from supersonic flow ( $M = 1 + 0$ ) or subsonic flow ( $M = 1 - 0$ ). In the former approach, the exact expressions of lift and lift distribution are obtained in terms of Fresnel integrals, while in the latter approach an integral equation must be solved, the kernel function of which is obtained from the subsonic Possio's equation and has a root singularity. The discrete analysis is adopted on the basis of the semi-circle method (SCM) and the weighting function for subsonic-flow-Gauss-quadrature, as well as modified

diagonal elements resulting from the root singularity. Aerodynamic characteristics obtained from both approaches agree quite well with each other. The results obtained by the present computations are compared with those of DLM-C (subsonic 2D code) developed by ANDO et al, and are found to give a reasonable outer boundary for subsonic unsteady aerodynamics. Author

**N87-14266#** National Aerospace Lab., Tokyo (Japan).

**NUMERICAL SIMULATION OF TRANSONIC FLOW FIELDS BY SOLVING THE THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS**

K. FUJII, M. YOSHIDA, and S. OBAYASHI In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 159-165 Nov. 1985 In JAPANESE; ENGLISH summary Avail: NTIS HC A12/MF A01

The LU-ADI factored scheme was successfully applied to solving the three-dimensional compressible thin-layer Navier-Stokes equations. The computations were performed for the slightly supersonic flow over a hemispheric cylinder at high incidence and for the transonic flow over a swept wing. To simulate these complicated flow fields, fine grid distributions up to about 200,000 points were used on a Japanese supercomputer. The total cpu time for each case was less than two hours. The result for the flow over a hemispheric cylinder at high incidence revealed the existence of the shock wave and the detailed structure of the vortical flow field on the leeward side. The improved version of the LU-ADI scheme was then developed and used for the simulation of the viscous transonic flow fields over the main wing of a practical transportation aircraft. Excellent agreement was obtained between the calculated pressure distribution over the surface and that of the experiment. The three-dimensional complicated separation phenomenon was also revealed for the case of relatively high angle of attack. These results indicate the capability of the present code to simulate three-dimensional complicated flow fields. The application of the present code to more practical flow fields such as transonic flows over a wing-body combination of transportation is very promising. Even simulation over the whole aircraft geometry may soon be possible. Author

**N87-14267#** National Aerospace Lab., Tokyo (Japan).

**THE RELIABILITY OF NUMERICAL SOLUTIONS FOR THE VISCOUS TRANSONIC FLOWS OVER AN AIRFOIL**

K. MATSUSHIMA, S. OBAYASHI, and K. FUJII In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 167-173 Nov. 1985 In JAPANESE; ENGLISH summary Avail: NTIS HC A12/MF A01

The transonic viscous flow field about an airfoil was computed using the LU-ADI algorithm. Several kinds of grid distribution were examined to evaluate the effect of the grid spacing and the orthogonality near the body surface. The computed results indicate that good representation of the geometry is very important for finite difference computation. The grid orthogonality is also important. The grid spacing should be small where the flow variable changes rapidly and conventional use of the grid does not suffice. Grid points near the boundary layer edge should also be carefully distributed. Author

**N87-14268#** National Aerospace Lab., Tokyo (Japan).

**COMPUTATIONAL STUDY OF FLOW AROUND AN AIRFOIL AT HIGH ANGLES OF ATTACK BY A BLOCK PENTADIAGONAL MATRIX METHOD**

Y. SHIDA and K. KUWAHARA In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 175-184 Nov. 1985 In JAPANESE; ENGLISH summary Avail: NTIS HC A12/MF A01

Two unsteady flows around an airfoil are studied by numerically solving the two-dimensional compressible Navier-Stokes equations. One is the flow around a NACA0012 airfoil at Mach 0.4 at an angle of attack of 15 degrees. The Reynolds number is 1000000. The other is the dynamic stall problem around a NACA0012 airfoil. The Mach number is 0.3. The Reynolds number is 4000000. The block pentadiagonal matrix scheme, a method which is based on the approximate factorization scheme, is adopted. In the former



case, a strong suction peak is observed near the leading edge in the computational results obtained by using a fine mesh. It appeared to be maintained by turbulence-like small vortices. In the case of the dynamic stall, two noteworthy features are observed in the computation using the fine mesh. The first is that when vortex separation occurs on the upstroke, many small vortices are separated from all parts of the surface, rather than just one large vortex from the leading edge as one might expect. The second is that the flow re-attaches when the angle of attack is about 8 degrees on the down-stroke. The lift stall is clearly captured in this study. Author

**N87-14271#** National Aerospace Lab., Tokyo (Japan).  
**TWO-DIMENSIONAL INCOMPRESSIBLE FLOWS AROUND AN AIRFOIL AT SEVERAL ATTACK ANGLES**  
 Y. NAKAMURA, M. ISHIGURO, and M. YASUHARA *In its* Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 217-227 Nov. 1985 In JAPANESE; ENGLISH summary  
 Avail: NTIS HC A12/MF A01

Two-dimensional incompressible flows were numerically solved for two problems, using stream function-vorticity formulation with second-order accuracy in space and first-order accuracy in time. First, flows around an NACA0012 airfoil were solved at a Reynolds number of 10000 at angles of attack up to 15. Separation and generation of vortices were well simulated. Secondly, this method was applied to a flow around a circulation controlled airfoil, where a jet was emitted along the airfoil surface. The result indicates that outside the jet near the trailing edge the flow is deflected downward and that vortices play a significant role at the initial stage. Author

**N87-14273#** National Aerospace Lab., Tokyo (Japan).  
**TRANSONIC AILERON COMPUTATION IN COMPARISON TO WIND TUNNEL TEST**  
 J. MIYAKAWA, N. HIROSE, and N. KAWAI *In its* Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 235-241 Nov. 1985 In JAPANESE; ENGLISH summary  
 Avail: NTIS HC A12/MF A01

The progress of computational aerodynamics over the past decade was so tremendous, partly pushed by the rapid advance in computer hardware, that aircraft designers have obtained an alternative tool for aerodynamic analysis comparable to wind tunnel testing. The Navier-Stokes computation, which was used successfully in research recently, is also likely to become a practical tool for analyzing viscous flows. NSFOIL, the high Reynolds number transonic airfoil analysis code developed at NAL, was verified by comparing it with the results of high Reynolds number wind tunnel tests. The NSFOIL computation of the transonic airfoil with aileron, is presented. To show the effectiveness of this code, the comparison of numerical results with the experiment is also presented. Author

**N87-14278\*#** Iowa State Univ. of Science and Technology, Ames. College of Engineering.  
**WING/BODY INTERFERENCE FLOW INVESTIGATION Ph.D. Thesis. Final Technical Report**  
 J. M. VOGEL and M. G. NAGATI 1986 112 p  
 (Contract NCC2-19; ERI PROJ. 1432)  
 (NASA-CR-179979; NAS 1.26:179979) Avail: NTIS HC A06/MF A01 CSCL 51A

The concept of using parametric bicubic patch surface definitions with bilinear vorticity or biquadratic doublet distributions was tested by modeling the vortex sheet and predicting its shape numerically in the vicinity of the wing. For the purpose of computing induced velocities, it was shown that higher order of vorticity would not improve the truncation error. The bilinear distribution, used to model the tip vorticity, was satisfactory but gave rise to some difficulty. The bicubic geometric surface representation proved very suitable for curved surfaces such as the rolled-up vortex sheet, with the surface fit scheme failing only for complex wings, far downstream beyond the region of concern. B.G.

**N87-14279\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**A VERIFICATION OF UNSTEADY NAVIER-STOKES SOLUTIONS AROUND OSCILLATING AIRFOILS**

J. NAKAMICHI Sep. 1986 31 p  
 (NASA-TM-88341; A-86337; NAS 1.15:88341) Avail: NTIS HC A03/MF A01 CSCL 51A

A finite difference solution code for the two dimensional Navier-Stokes equations was combined with a moving-grid system. The thin layer Navier-Stokes equations with a turbulence model are solved in a time-accurate manner in order to study the unsteady aerodynamics around airfoils undergoing small amplitude pitching or heaving motions in the transonic regime. The accuracy of the solutions obtained by the use of the present moving-grid technique is investigated. The effects of the minimum grid size and the integrating time-step size on the solutions are also checked. Some of the solutions obtained by the present method are compared with experimental results. It is demonstrated that the unsteady aerodynamics around oscillating airfoils can be predicted fairly well by the present code for cases in which the dynamic angle of attack or displacement is small. Author

**N87-14280\*#** National Aeronautics and Space Administration, Washington, D.C.  
**AERODYNAMIC CHARACTERISTICS OF GENERAL AVIATION AT HIGH ANGLE OF ATTACK WITH THE PROPELLER SLIPSTREAM**

N. MATSUO and S. HIRANO Sep. 1986 21 p Transl. into ENGLISH from Japan Society for Aeronautical and Space Sciences Journal, v. 33, no. 377, Jun. 1985 p 326-332 Original language document was announced in IAA as A86-25204 Transl. by Kanner (Leo) Associates, Redwood, City, Calif.  
 (Contract NASW-4005)  
 (NASA-TM-88503; NAS 1.15:88503; ISSN-0021-4663) Avail: NTIS HC A02/MF A01 CSCL 51A

The aerodynamic characteristics of the FA-300 business aircraft at high angle of attack with the propeller stream are described. The FA-300 offers two types, FA-300-700 for 340 HP, and -710 for 450 HP of the engine. The effects of the propeller slipstream on the high angle of the attack are discussed. Author

**N87-14282\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**HIGH LIFT, LOW PITCHING MOMENT AIRFOILS Patent Application**

K. W. NOONAN, inventor (to NASA) 5 Sep. 1986 30 p  
 (NASA-CASE-LAR-13215-1; NAS 1.71:LAR-13215-1;  
 US-PATENT-APPL-SN-904132) Avail: NTIS HC A03/MF A01 CSCL 51A

Two families of airfoil sections which can be used for helicopter/rotorcraft rotor blades or aircraft propellers of a particular shape are prepared. An airfoil of either family is one which could be produced by the combination of a camber line and a thickness distribution or a thickness distribution which is scaled from these. An airfoil of either family has a unique and improved aerodynamic performance. The airfoils of either family are intended for use as inboard sections of a helicopter rotor blade or an aircraft propeller. The novelty appears to reside in the specific shapes of the airfoil profiles which simultaneously permit high maximum lift coefficients at Mach numbers up to 0.50, low pitching moment coefficients about the quarter chord for lift coefficients from -0.2 to 1.0 at Mach numbers up to 0.63, and high drag divergence Mach numbers at lift coefficients from 0.0 to 0.30. NASA



## 02 AERODYNAMICS

**N87-14285#** Delaware Univ., Newark. Dept. of Mechanical and Aerospace Engineering.

### **TURBULENCE MODELING FOR STEADY THREE-DIMENSIONAL SUPERSONIC FLOWS Final Report**

J. E. DANBERG, P. VANGULICK, and J. KIM Jun. 1986 63 p  
Sponsored by BRL

(AD-A170042; BRL-CR-553) Avail: NTIS HC A04/MF A01  
CSCL 20D

The Jones and Launder two-equation model of turbulence has been formulated and applied to the solution of supersonic, three-dimensional flow and the results compared to experimental data. Two solution techniques were studied, the boundary layer theory approach and the parabolized Navier-Stokes method formulated in a body fitted coordinate system. The K-E turbulence model results were compared with an algebraic turbulence model as applied to the prediction of flow about a spinning ogive-cylinder-boattail configuration. The K-E model gave slightly superior results in both the boundary layer and PNS computations. Rotta's non-isotropic theory for the Reynolds stresses was incorporated into the formulation. Results for the small angle of attack configuration showed little effect of non-isotropy. The cross flow properties are the most strongly affected. Bradshaw's streamline curvature theory was also considered and the results show negligible influence for the present case. GRA

**N87-14288#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

### **SIMPROP: A SYSTEM FOR SIMPLE AERODYNAMIC ANALYSIS OF PROPELLERS IN AXIAL FLOW. DESCRIPTION OF METHOD AND USER'S GUIDE**

T. E. LABRUJERE and A. KASSIES 31 Dec. 1984 46 p  
(Contract NIVR-1968)  
(NLR-TR-84128-U; B8671295; ETN-86-98651) Avail: NTIS HC A03/MF A01

A program system (SIMPROP) for simple aerodynamic analysis of propellers in axially symmetric flow is described. A vortex and a momentum method, both based on trip theory, are used for the calculation of induced velocities. The required two dimensional airfoil characteristics are obtained by computer programs based on finite difference methods for the calculation of viscous transonic flow. Numerical results agree with measured data. ESA

**N87-14289#** European Space Agency, Paris (France). **INVESTIGATION OF FERRI INSTABILITY IN SUPERSONIC INLETS**

E. O. KROHN and K. TRIESCH Jun. 1986 32 p Original language document was announced as N86-21524 (ESA-TT-978; DFVLR-FB-85-53; ETN-87-98825) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne, West Germany, DM 13

Ferri instability, caused by the inflow of a discontinuity surface (slipline) in the inlet was studied. A criterion for the appearance of the Ferri instability was derived. Flat inlets are most, and semirotationsymmetric inlet the least, sensitive to Ferri instability. Means to avoid the instability are discussed. Strength and penetration depth of the slipline play a role in triggering the instability, although this role is not clarified. ESA

**N87-14291#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Hauptabteilung Windkanale.

### **EXPERIENCE ABOUT THE APPLICATION AND VALUATION OF ROUGHNESS STRIPS FOR BOUNDARY LAYER TRANSITION CONTROL IN WIND TUNNEL TESTS IN THE HIGH-SPEED RANGE**

S. TUSCHE Apr. 1986 91 p In GERMAN; ENGLISH summary  
(DFVLR-MITT-86-12; ISSN-0176-7739; ETN-87-98852) Avail: NTIS HC A05/MF A01; DFVLR, Cologne, West Germany DM 56

Placing and application of artificial transition strips for aerodynamic tests are described. Methods used in high speed wind tunnels for checking the effectiveness of transition strips are given. ESA

**N87-14292#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Trans-Ueberschall-Entwurfsverfahren.

### **A CALCULATION METHOD FOR THE PROPULSIVE JET AND ITS AERODYNAMIC INTERACTION WITH AN AFTERBODY Ph.D. Thesis - Technische Univ., Brunswick, West Germany**

R. RADESPIEL Jun. 1986 117 p In GERMAN; ENGLISH summary  
(DFVLR-FB-86-29; ISSN-0171-1342; ETN-87-98858) Avail: NTIS HC A06/MF A01

A calculation method for single and multistream jet flows and their aerodynamic interaction with an afterbody is developed. The governing equations of viscous and inviscid flow fields are given in natural coordinates of the viscous flow. A transpiration model takes into account the viscous inviscid interactions. Reynolds stresses and turbulent heat fluxes are calculated using kinetic energy, dissipation rate, and intermittency factor of turbulence. The calculation method is applied on classical boundary layer flows, then verified by calculations of flows around afterbodies with single and two stream jets. ESA

**N87-14636#** Royal Aircraft Establishment, Farnborough (England).

### **MODELING THREE DIMENSIONAL VORTEX FLOW IN AERODYNAMICS**

J. H. B. SMITH In Von Karman Inst. for Fluid Dynamics Introduction to Vortex Dynamics, Volume 1 67 p 1986  
Avail: NTIS HC A14/MF A01

Streamlines, vorticity, flow separation, and attachment and reattachment are discussed. Inviscid modeling of separated flows is introduced. The initial behavior of a vortex sheet, and vortex decay are considered. Inviscid models for sharp edged wings, and separation from smooth surfaces are described. ESA

**N87-14641#** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

### **COMPRESSIBILITY EFFECTS ON DELTA WING FLOW FIELDS**

G. VORROPOULOS and J. F. WENDT In its Introduction to Vortex Dynamics, Volume 2 36 p 1986  
Avail: NTIS HC A14/MF A01

The axial and tangential velocity components in the leading edge vortex of an aspect ratio 2, planar delta wing of 10 deg incidence were measured by laser Doppler velocimetry in the Mach number range from 0.18 to 0.80. For sufficiently high Mach numbers, the axial velocity distribution through the vortex exhibits a minimum near the vortex axis, instead of a maximum as under incompressible conditions. The axial velocity distribution becomes asymmetric about the vortex axis with increasing Mach number. Asymmetry is observed in the spanwise distribution of the tangential velocity for  $M = 0.80$ . The measurements do not support the theoretical model of the compressible conical vortex of Brown which assumed axisymmetric flow. It is postulated that the appearance of a local supersonic pocket and attendant shock wave is responsible for the development of the strong asymmetries; evidence from computations employing the Euler equations lends support. ESA

**N87-14642#** Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

### **COMPRESSIBILITY EFFECTS ON FLOWS AROUND SIMPLE COMPONENTS**

J. F. WENDT In its Introduction to Vortex Dynamics, Volume 2 21 p 1986  
Avail: NTIS HC A14/MF A01

The effects of compressibility on the flow fields and overall aerodynamic characteristics of low aspect ratio, sharp-edged planforms (rectangular, trapezoidal, and delta) and long ogive-cylinders at high incidence are considered. The leeside vortex-dominated flow structure, including vortex bursting is emphasized. Subsonic and supersonic regimes are included; unsteady effects are not considered. ESA

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

## A87-17418

## STANDARDIZING AIR CARGO CONTAINERS

J. C. SIMMONS and R. V. RIGGS Aerospace Engineering (ISSN 0736-2536), vol. 6, Sept. 1986, p. 38-45.

An evaluation is made of efforts to date toward the most volumetrically efficient use of existing wide body commercial aircraft for containerized cargo carriage. The aircraft in question are the 747, DC 10, L-1011, A300, and A310 airliners. A comparison of aircraft interior cross sections demonstrates the usefulness of standardization of 96- and 125-inch wide pallets. Upper and lower aircraft deck containers are compared, and plans to produce adaptable pallets are described. O.C.

## A87-17809#

## CORRELATION OF ICING RELATIONSHIPS WITH AIRFOIL AND ROTORCRAFT ICING DATA

R. J. FLEMMING and D. A. LEDNICER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 737-743. Previously cited in issue 07, p. 851, Accession no. A85-19680. refs

A87-17995\*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

## IN-FLIGHT PHOTOGRAMMETRIC MEASUREMENT OF WING ICE ACCRETIONS

R. C. MCKNIGHT (NASA, Lewis Research Center, Cleveland, OH), R. L. PALKO, and R. L. HUMES (Carlspace Corp., Arnold Air Force Station, TN) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p. Previously announced in STAR as N86-31562. refs (AIAA PAPER 86-0483)

A photographic instrumentation system was developed for the Lewis icing research aircraft to measure wind ice accretions during flight. The system generates stereo photographs of the accretions which are then photogrammetrically measured by the Air Force Arnold Engineering and Development Center. The measurements yield a survey of spatial coordinates of an accretion's surface to an accuracy of at least + or - 0.08 cm. The accretions can then be matched to corresponding icing cloud and aerodynamic measurements. The system is being used to measure rime, mixed, and clear natural ice accretions. Author

## A87-19251

## THE DEVELOPMENT OF DYNAMIC PERFORMANCE STANDARDS FOR CIVIL ROTORCRAFT SEATS

J. H. MAJOR (FAA, Helicopter Directorate, Fort Worth, TX) and S. J. SOLTIS (FAA, Long Beach, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 623-633. refs

Civil aircraft seats have traditionally been designed to comply with static strength requirements. Dynamic performance standards which address both seat strength and the occupant impact protection characteristics of the seat have recently been defined for aircraft seats. The FAA has funded a program to research U.S. rotorcraft accidents. Accident scenarios were developed from this research. Further analysis of the results of those data led to the formulation of new dynamic performance standards for rotorcraft seats and occupant restraint. The FAA has proposed that those newly developed seat dynamic performance criteria be incorporated into Parts 27 and 29 of the Federal Aviation Regulations. The development of those standards is reviewed. Author

N87-13419# National Transportation Safety Board, Washington, D. C.

## AIRCRAFT ACCIDENT REPORT: HENSON AIRLINES BEECH B99, N339HA, GROTTOS, VIRGINIA, SEPTEMBER 23, 1985

23 Sep. 1985 87 p (PB86-910409; NTSB-AAR-86-07) Avail: NTIS HC A05/MF A01 CSCL 01C

Henson Airlines Flight 1517, a Beech B99, was cleared for an instrument approach to the Shenandoah Valley Airport, Weyers Cave, Virginia, at 0959 on September 23, 1985, after a routine flight from Baltimore-Washington International Airport, Baltimore, Maryland. Instrument meteorological conditions prevailed at Shenandoah Valley Airport. There were 12 passengers and 2 crewmembers aboard the scheduled domestic passenger flight operating under 14 CFR 135. Radar service was terminated at 1003. The crew of flight 1517 subsequently contacted the Henson station agent and Shenandoah UNICOM. The last recorded radar return was at 1011, at which time the airplane was east of the localizer course at 2,700 feet mean sea level and on a magnetic track of about 075 deg. At 1014 the pilot said, ... we're showing a little west of course... and at 1015 he asked if he were east of course. At 1017, the controller suggested a missed approach if the airplane was not established on the localizer course. There was no response from the crew of flight 1517 whose last recorded transmission was at 1016. The wreckage of flight 1517 was located about 1842 approximately 6 miles east of the airport. Both crewmembers and all 12 passengers were fatally injured. Author

N87-13420# Federal Aviation Administration, Washington, D.C. Office of Civil Aviation Security.

## SEMIANNUAL REPORT TO CONGRESS ON THE EFFECTIVENESS OF THE CIVIL AVIATION SECURITY PROGRAM Recurring Report, 1 Jul. - 31 Dec. 1985

30 May 1986 17 p (AD-A169813; DOT/FAA/ACS-85-2(23)) Avail: NTIS HC A02/MF A01 CSCL 01E

This report provides details on the effectiveness of security screening of passengers and all property intended to be carried in the aircraft cabin in air transportation or intrastate air transportation. It also provides a statistical summary of aircraft hijackings and alleged violations of Federal Aviation regulations pertaining to security screening. In addition, the report presents a summary of the assessments conducted to determine the effectiveness of the security measures at foreign airports served by U.S. air carriers and certain other foreign airports as required by Section 1115 of the Federal Aviation Act of 1958, as amended. Author (GRA)

N87-14296 Civil Aviation Authority, London (England). Safety Data and Analysis Unit.

## ANALYSIS OF BIRD STRIKES REPORTED BY EUROPEAN AIRLINES 1976-1980. CIVIL AIRCRAFT OVER 5700 KG (12 500 LB) MAXIMUM WEIGHT

J. THORPE Dec. 1984 30 p (CAA-PAPER-84019; ISBN-0-86039-231-7; ETN-87-98597) Avail: Issuing Activity

Over 7300 bird strikes reported world-wide between 1976 and 1980 by European airlines from 14 countries were analyzed. The analysis includes the annual strike rate for each country, for aircraft types, and airports, all based on aircraft movements. It also covers bird species and weights, part of aircraft struck, effect of strike, and cost. Results show that gulls were involved in over 40% of the incidents where the type of bird was known, and that only 1% of bird strikes involves birds of over 4 lb. The major effects are damage to over 330 engines and the loss of a Boeing 737 and a Learjet (total value \$6 million). Engineering costs are estimated at \$17 million excluding the Boeing 737 and Learjet. ESA

### 03 AIR TRANSPORTATION AND SAFETY

**N87-14297** Civil Aviation Authority, London (England). Safety Data and Analysis Unit.

**ACCIDENTS TO UK AIRCRAFT AND TO LARGE JET AND TURBO-PROP TRANSPORT AIRCRAFT WORLDWIDE IN 1984**

Jun. 1985 25 p

(CAA-PAPER-85009; ISBN-0-86039-241-4; ETN-87-98600) Avail: Issuing Activity

The 1984 accident statistics for all UK aircraft, all jet and turboprop airplanes of more than 5700 kg and all helicopters of more than 4500 kg worldwide are presented. A total of 99 accidents, of which 24 were fatal (369 deaths) is reported. ESA

**N87-14299** Civil Aviation Authority, London (England). Safety Data and Analysis Unit.

**ANALYSIS OF BIRD STRIKES TO UNITED KINGDOM REGISTERED AIRCRAFT 1983 (CIVIL AIRCRAFT OVER 5700 KG MAXIMUM WEIGHT)**

J. THORPE Nov. 1985 21 p

(CAA-PAPER-85018; ISBN-0-86039-264-3; ETN-87-98604) Avail: Issuing Activity

Bird strikes reported throughout the world in 1983 by UK airlines were analyzed. The analysis includes rates for aircraft type and operators reporting based on aircraft movements. It also covers aerodromes, bird species, and effect of strike. The reported strike rate in 1983 is the same as in 1982. Gulls (*Larus* spp.) were involved in 40% of incidents where the bird species were identified. The major effect is damage to 16 engines, with 9 cases of ingestion in more than one engine. ESA

**N87-14300** Civil Aviation Authority, London (England).

**WIND SHEAR AND FLIGHT SAFETY: A SELECT BIBLIOGRAPHY**

Apr. 1986 41 p

(CAA-PAPER-86003; ISBN-0-86039-279-1; ETN-87-98605) Avail: Issuing Activity

Almost 200 references covering wind shear and flight safety are listed. ESA

**N87-14301** Civil Aviation Authority, London (England). Safety Data and Analysis Unit.

**ACCIDENTS TO UNITED KINGDOM AIRCRAFT AND TO LARGE JET AND TURBO-PROP TRANSPORT AIRCRAFT WORLDWIDE IN 1985**

May 1986 25 p

(CAA-PAPER-86005; ISBN-0-86039-277-5; ISSN-0269-4948; ETN-87-98606) Avail: Issuing Activity

The 1985 accident statistics for all UK aircraft, all jet and turboprop airplanes of more than 5700 kg and all helicopters of more than 4500 kg worldwide are presented. A total of 143 accidents, of which 42 were fatal (2033 deaths) is reported. ESA

**N87-14303** Civil Aviation Authority, London (England). Medical Research Council Applied Psychology Unit.

**AUDITORY WARNINGS ON THE BAC 1-11 AND THE BOEING 747. AN APPLICATION OF THE GUIDELINES OF CAA PAPER 82017 Final Report**

R. D. PATTERSON, R. MILROY, and J. BARTON Feb. 1985 61 p

(Contract CAA-7D/S/0260/1)

(CAA-PAPER-85004; ISBN-0-86039-234-1; ETN-87-98598) Avail: Issuing Activity

In order to verify the sound volume aspects of guidelines for the design of auditory warnings in aircraft two warnings in existing civil aircraft were assessed. One is frequently criticized as being too loud and the other as being too quiet. Neither warning is found to conform to the guidelines. ESA

**N87-14304** Royal Air Force Inst. of Aviation Medicine, Farnborough (England). Aircrew Equipment Group.

**EMERGENCY EXITS FOR UNDERWATER ESCAPE FROM ROTORCRAFT**

J. R. ALLAN and F. R. C. WARD Jan. 1986 19 p

(AEG-REPT-528; BR98781; ETN-87-98622) Avail: NTIS HC A02/MF A01

An experimental adjustable escape exit was used to determine the smallest rectangular exit compatible with underwater escape by passengers in the upper range of shoulder widths and wearing standard immersion protection. An exit 432 mm (17 in) x 356 mm (14 in) is considered to be the smallest acceptable size. Recommendations in respect to swimming goggles, hand-holds, and opening systems, and for a review of the advantages of a larger number of smaller escape exits for ditching emergencies are made. ESA

**N87-14305\*#** National Aeronautics and Space Administration, Washington, D.C.

**ACCIDENT OF THE DC-10 EC-DEG AIRCRAFT AT MALAGA ON SEPTEMBER 13, 1982**

Oct. 1986 18 p Transl. into ENGLISH from IAA/Ingenieria Aeronautica y Astronautica (Spain), Jan. 1986 p 24-31 Original language document was announced in IAA as A86-31011 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.

(Contract NASW-4006)

(NASA-TM-88007; NAS 1.15:88007; ISSN-0020-1006) Avail: NTIS HC A02/MF A01 CSCL 85D

The present analysis of the abortive takeoff-type accident of a DC-10 at Malaga airport gives attention to the velocity profiles of the aircraft from takeoff to ground impact. A fire followed ground impact. Takeoff was initiated by the crew with only 1295 m of runway left beneath the aircraft. On the basis of the data obtained by this analysis, it is recommended that both pilots and other flight crew members be trained to respond to takeoff failures due to causes other than loss of engine power, such as landing gear collapse. Author

**N87-14306#** Simula, Inc., Phoenix, Ariz.

**COMPUTER SIMULATION OF A TRANSPORT AIRCRAFT SEAT AND OCCUPANT(S) IN A CRASH ENVIRONMENT, VOLUME 1 Final Report, Jun. 1983 - Mar. 1986**

A. O. BOLUKBASI and D. H. LAANANEN Aug. 1986 139 p

(Contract DTFA03-83-00036)

(DOT/FAA/CT-86/25-1; TR-84430-VOL-1) Avail: NTIS HC A07/MF A01

A mathematical model of a transport aircraft seat, occupants, and restraint system has been developed for use in analysis of transport aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a finite element model of the seat structure is included. The seat model can accommodate large plastic deformations and includes the capability for simulation of local buckling of bending members. Because the program was written for use primarily by engineers concerned with the design and analysis of seat and restraint systems, an effort was made to minimize the input data required to describe the occupant. This is Volume 1 of a two-volume document. This volume discusses development of the mathematical model of the occupants, the finite element seat analysis, validation, and organization of the computer program. Author

**N87-14307#** Simula, Inc., Phoenix, Ariz.

**COMPUTER SIMULATION OF A TRANSPORT AIRCRAFT SEAT AND OCCUPANT(S) IN A CRASH ENVIRONMENT. VOLUME 2: PROGRAM SOM-TA USER MANUAL**

A. O. BOLUKBASI and D. H. LAANANEN Aug. 1986 211 p

(Contract DTFA03-83-C-0036)

(DOT/FAA/CT-86/25-2; TR-84429-VOL-2) Avail: NTIS HC A10/MF A01

A mathematical model of a transport aircraft seat, occupants, and restraint system was developed for use in analysis of transport aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a finite element model

of the seat structure is included. The seat model can accommodate large plastic deformations and includes the capability for simulation of local buckling members. Because the program was written for use primarily by engineers concerned with the design and analysis of seat and restraint systems, an effort was made to minimize the input data required to describe the occupants. This is Volume 2 of a two-volume document. This volume contains instructions for preparing input data and operating the program, supported by detailed examples. Sample material properties and modeling parameters are also included. Author

## 04

**AIRCRAFT COMMUNICATIONS AND NAVIGATION**

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A87-16749****ECCM/ADVANCED RADAR TEST BED (E/ARTB) SYSTEM DEFINITION**

P. J. GROS, JR., D. E. SAMMONS, and A. C. CRUCE (BDM Corp., Dayton, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 251-257.

A test bed for evaluating ECCM/radar system requirements and effectiveness is proposed. The test bed is a reprogrammable design with an extendable and modular architecture that has the ability to rapidly and economically fulfill new requirements. A list of the ECCM/radar system requirements is presented. The interface, data recording, computing, and data presentation capabilities of the system are discussed. The operation and communications architecture for the instrumentation system are described. I.F.

**A87-16750****NAVIGATIONAL COORDINATE SYSTEMS - HOW TO GET YOUR SURFACE AND AIR POSITIONING VERY PRECISE AND STILL BE OFF BY 20 NAUTICAL MILES**

S. B. RICHTER and D. M. PARRY (Aydin Computer Systems, Horsham, PA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 268-272. refs

**A87-16751#****SYNTHESIS AND TEST ISSUES FOR FUTURE AIRCRAFT INERTIAL SYSTEMS INTEGRATION**

D. J. BIEZAD (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 279-285. refs

This paper surveys the potential benefits, possible pitfalls, and anticipated testing needs of integrating inertial guidance systems with systems dependent upon the availability of the electromagnetic spectrum. Advance preparations for testing integrated modules include upgraded and shared time reference standards on military aircraft, the development of expertise in modular filtering, and the consideration of new test criteria for systems with embedded intelligence in its component subsystems. Author

**A87-16752****COMPARISON OF METHODS FOR EXPANDING THE CONVERGENCE REGION OF SITAN SYSTEM**

H. CHEN, M. JI, Z. SHEN, and Z. SUN (Changsha Institute of Technology, People's Republic of China) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 288-292. refs

Three methods for expanding the convergence region of the SITAN system are discussed. The performances of the state extension method, parallel filtering with adaptive sequential decision method, and the terrain contour algorithm based on the recursive calculation of the posterior probability density function are evaluated and compared. It is observed that the state extension method is useful for eliminating the correlation of the linearization errors and the parallel filtering method can expand the convergence region to the complete stored area. I.F.

**A87-16753****THE STABILITY OF KALMAN FILTER IN INERTIAL NAVIGATION SYSTEMS**

J. YU (Northwestern Polytechnical University, Xian, People's Republic of China) and J. C. HUNG (Tennessee, University, Knoxville) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 293-298. refs

This paper offers a new sufficient condition for filtering stability of Kalman filter. This condition is believed to be weaker than other known sufficient conditions. Inertial navigation systems, which do not satisfy this sufficient condition, may still have satisfactory Kalman filters. This can often be determined by examining the forms of the associated system vectors and matrices. Author

**A87-16814****TERRAIN-BASED INFORMATION - A REASON TO INTEGRATE**

R. M. BOYS (Texas Instruments, Inc., Dallas) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1986, p. 888-893. USAF-supported research. refs

The Integrated Terrain Access/Retrieval System (ITARS) is a digital map system designed under competitive contract for the Air Force Wright Aeronautical Laboratories (Aeronautical Systems Division). This paper discusses the ITARS human factors design issues, particularly those related to display formats. An emphasis is placed on the terrain-based nature of the information that the system is capable of providing to various display subsystems. It is argued that a pictorial, terrain-based information set is particularly salient and should ease pilot workload and improve performance by facilitating the man/machine interface. The potential applications of digital maps are also discussed. Author

**A87-16835****DESIGN FOR MAINTAINABILITY - LITTON'S NEW FAMILY OF RLG INERTIAL NAVIGATION SYSTEMS**

R. COX, D. FAVARO, and E. THIESEN IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1115-1119. (Contract F33657-85-C-2158)

Design and operational features of two military ring laser gyro (RLG) Systems, the LN-93 and LN-94 units, are summarized. Both systems have digital and analog interfaces and chassis that permit interchangeability with current systems and compatibility with future systems. Commonality extends to software modules, test equipment and built-in self-test (BIT) circuitry. Details of the sensor assembly, inertial data and gyro control card, navigation processor, and low voltage power supply are discussed, along with BIT capabilities which perform turn-on, periodic and manual control circuitry checks. M.S.K.

A87-16845

**ADAPTIVE TACTICAL NAVIGATION CONCEPTS**

S. BERNING (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), D. P. GLASSON (Analytic Sciences Corp., Reading, MA), and J. A. GUFFEY (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1235-1242. refs  
(Contract F33615-83-C-1111; F33615-83-C-1112)

Two attempts to develop AI-based tactical aircraft navigation systems are described. The McDonnell Aircraft Adaptive Tactical Navigation (ATN) study was directed at defining an adaptive, self-reconfiguring navigation system, the technologies needed to produce it, and the expected benefits. An event-driven approach was adopted in the MCAIR system, which accounts for the mission, mission phase, the pilot priorities, etc. Studies showed that an ATN would reduce pilot workload and error, improve performance and add new capabilities. The knowledge base for a second ATN, the TASC, was defined after querying aircrew personnel and quantifying the navigation accuracy required for weapons delivery.

M.S.K.

A87-16987#

**MODERN FLIGHT CONTROL FROM THE POINT OF VIEW OF THE COCKPIT [MODERNE FLUGZEUGFUEHRUNG AUS DER SICHT DES COCKPITS]**

J. VOIGT (Deutsche Lufthansa AG, Hamburg, West Germany) *Ortung und Navigation* (ISSN 0474-7550), vol. 27, no. 2, 1986, p. 170-173. In German.

The traditional tasks of the cockpit crew in flying transport aircraft, operating and monitoring aircraft systems, and planning and carrying out the flight mission are defined; and the impact of technological advances on each is described. Consideration is given to autopilot functions, redundant self-monitoring and fault-correction systems, improved airway and airport-zone maps, computer flight-plan-optimization techniques, long-range navigation, standardization of short-range routes and flight plans, and advanced flight-management systems.

T.K.

A87-16988#

**RADAR-SUPPORTED TRAFFIC MONITORING SYSTEMS FOR MARITIME AND AIR SAFETY [RADARGESTUEZTE VERKEHRSUEBERWACHUNGSSYSTEME FUEER DIE MARITIME SICHERHEIT UND DIE LUFTSICHERHEIT]**

A. LIEBELT and R. KELLER (Telefunken AG, Frankfurt am Main, West Germany) *Ortung und Navigation* (ISSN 0474-7550), vol. 27, no. 2, 1986, p. 193-214. In German. refs

The design and operation of two computerized radar-based traffic-management systems, one for maritime and one for ATC use, are described and illustrated. Maritime-system features discussed include moving-window-integrator/SIMAD target extraction, tracking processor with interactive display and automatic collision warning, radar work stations, and ship-movement extrapolation programs. The ATC system is analogous and employs moving-target detectors, Doppler processors, and parameter extractors for target extraction; monoradar and multiradar target tracking; and synthesized ATC-status displays.

T.K.

A87-16989#

**DISPLAY OF NAVIGATION INFORMATION ON AIRCRAFT SCREENS [DARSTELLUNG VON NAVIGATIONSINFORMATIONEN AUF BILDSCHIRMEN IM FLUGZEUG]**

J. VOIGT (Deutsche Lufthansa AG, Hamburg, West Germany) *Ortung und Navigation* (ISSN 0474-7550), vol. 27, no. 2, 1986, p. 262-265. In German.

The design and operation of an onboard computerized flight-management system used on the A310 are briefly characterized and illustrated with drawings and sample displays. Consideration is given to the general and carrier-specific contents of a typical navigational database (contained on a 6.144-MB hard disk in the case of the A310 system); the keyboard callup and

color CRT display of navigation data on the electronic flight instrument system; and the rose, arc, map, and plan display modes.

T.K.

A87-17243

**CHARACTERIZING HEIGHT-KEEPING ERROR DISTRIBUTION BASED ON INDIRECT OBSERVATION**

S. NAGAOKA (Electronic Navigation Research Institute, Tokyo, Japan) *Journal of Navigation* (ISSN 0020-3009), vol. 39, Sept. 1986, p. 416-423. refs

The relation between the distribution of the height-keeping errors (HKEs) and relative vertical distances (RVDs), based on observation data, is presented. Modeling of probability density functions based on HKE distributions is described. Comparison of the goodness of the fit for several models of the pdf were conducted. Assuming that the HKE distribution of an aircraft is the double exponential or double-double exponential, and that of the measurement errors is the Gaussian, the results indicate that the derived models of the RVDs fit well to the empirical distribution.

I.S.

A87-17244

**THE COST-EFFECTIVENESS OF TERRESTRIAL RADIO-NAVIGATION**

M. G. PEARSON *Journal of Navigation* (ISSN 0020-3009), vol. 39, Sept. 1986, p. 424-438. refs

The cost-effectiveness of terrestrial radio navigation was estimated. The approach taken was to assess the number of radio navigation point-source aids on a worldwide basis and to apportion detailed costs to each type of facility. The major radio navigation systems that are in use today are presented, together with the range of these systems and their accuracy, as well as the approximate number of users, such as marine navigation vessels, supply and drill ships, and helicopters.

I.S.

A87-17586

**FEATURES OF ANTENNA APERTURE SYNTHESIS FOR AN ARBITRARY FLIGHT-VEHICLE TRAJECTORY [OSOBENOSTI SINTEZIROVANIYA APERTURY ANTENNY PRI PROIZVOL'NOI TRAEKTORII LETATEL'NOGO APPARATA]**

N. A. SAZONOV *Radiotekhnika* (ISSN 0033-8486), Aug. 1986, p. 89-92. In Russian. refs

It is shown that, for an arbitrary trajectory of a flight vehicle with a synthetic-aperture radar, the support function should be calculated for each synthesis interval (SI). For the parabolic approximation of the distance between the phase center of the antenna and points on the earth surface, it is sufficient to calculate this function just once on the SI. The determination of the maximum synthesis time and the frame size of the radar image for an arbitrary trajectory is also considered.

B.J.

A87-17702

**AUTOMATED AIRCRAFT NAVIGATION [AVTOMATIZIROVANNOE VOZHDENIE VOZDUSHNYKH SUDOV]**

I. G. KHIVRICH and A. M. BELKIN *Moscow, Izdatel'stvo Transport*, 1985, 328 p. In Russian. refs

The theoretical principles of the automatic navigation of civil aircraft using a navigation and flight control complex are examined. In particular, attention is given to the fundamentals of the automatic navigation of aircraft under various conditions, a general characterization of radio navigation systems, the use of Doppler velocimeters and angular accelerometers, the use of airborne radar stations, and the use of satellite-based navigation systems.

V.L.

A87-18533#

**AN OPEN-LOOP INITIAL ALIGNMENT SCHEME FOR STRAPDOWN INERTIAL NAVIGATION SYSTEMS**

Z. CUI and G. SHI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) *Acta Aeronautica et Astronautica Sinica*, vol. 7, Aug. 1986, p. 377-384. In Chinese, with abstract in English. refs

A tactical open-loop alignment scheme for strapdown inertial navigation systems is discussed in detail. The alignment process

is separated into two steps, i.e., coarse alignment (or analytical alignment), and open-loop fine alignment. Digital simulations are employed to verify the effectiveness of such an alignment scheme. The simulation results reveal that this scheme can reach an accuracy superior to 1 arc-minute in azimuth misalignment and less than 6 minutes is needed to complete the alignment process under the simulation conditions. Other results also indicate that this scheme is efficient and satisfactory. Author

#### A87-18534#

##### THE APPLICATION OF ALTITUDE OBSERVATION IN CNI RELATIVE NAVIGATION

D. WANG and Z. DING (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Aug. 1986, p. 393-398. In Chinese, with abstract in English.

Results of computer simulation show that a communication, navigation and identification (CNI) integrated system has a larger estimation error in altitude if there is not any other observation. The error can be reduced by using altitude observations. In practice the Kalman filter can be decoupled on the basis of the distribution of members of the CNI system. Author

#### A87-19351

##### INSTITUTE OF NAVIGATION, ANNUAL MEETING, 42ND, SEATTLE, WA, JUNE 24-26, 1986, PROCEEDINGS

Washington, DC, Institute of Navigation, 1986, 179 p. For individual items see A87-19352 to A87-19367.

The conference presents papers on the analysis of range and position comparison methods as a means of providing GPS integrity in the user receiver, a software package for predicting the performance of VLF-navigation systems, and measurement errors in GPS observables. Other topics include the architecture and performance of a real time differential GPS ground station, optimal locations of pseudolites for differential GPS, and GPS receiver technologies. Consideration is also given to Australian trials of Phase II Navstar GPS user equipment and the sensitivity of an autonomous navigation landmark tracing system due to the variability of landmark availability and distribution. K.K.

#### A87-19353#

##### GPS FAILURE DETECTION BY AUTONOMOUS MEANS WITHIN THE COCKPIT

R. G. BROWN and P. Y. C. HWANG (Iowa State University of Science and Technology, Ames) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 5-12. FAA-supported research. refs

The Magill adaptive filter scheme is proposed for autonomous GPS failure detection within the cockpit. The adopted approach involves the on-line calculation of the posteriori probabilities of various hypotheses and then making the decisions accordingly. Preliminary results suggest that soft ramp-type satellite clock failures can be detected and identified in a relatively short time given the low dynamical environment that might be encountered in the high-altitude enroute situation. K.K.

#### A87-19357#

##### MEASUREMENT ERRORS IN GPS OBSERVABLES

R. L. GREENSPAN and J. I. DONNA (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 55-60. USGS-Army-sponsored research.

Airborne users of GPS may benefit from differential (relative) navigation to the extent that the errors in their measurements of pseudorange and/or delta range to each satellite are correlated with observation errors for the same satellite signals received at a reference site. This paper describes some results of an experiment to characterize the measurement errors of one airborne GPS user equipment. The results suggest that pseudorange errors are dominated by slowly varying systematic processes that are likely to be highly correlated from user to user, whereas delta-range

errors appear to be zero-mean processes that are dominated by user generated noises, especially clock jitter. Author

#### A87-19360#

##### MEASUREMENT CAPABILITY OF MOVING-RECEIVER RADIO INTERFEROMETRY

S. J. BRZEZOWSKI, R. C. MERENYI, and W. G. HELLER (Analytic Sciences Corp., Reading, MA) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 92-98. refs (Contract F19628-83-C-0146)

The position, velocity, and acceleration measurement capability of moving-receiver radio interferometry was evaluated using covariance analysis techniques based on optimal Kalman smoothing with appropriate models for environmental and mechanical error sources. The sensitivity of measurement accuracy to such operational parameters as vehicle speed, the placement of atmospheric refractivity sensors, and the quality of those sensors is studied as well. It is concluded that radiointerferometry employing a mobile GPS receiver is capable of providing highly accurate navigation and geodetic information. K.K.

#### A87-19362#

##### AUSTRALIAN TRIALS OF PHASE II NAVSTAR GPS USER EQUIPMENT

R. HARDCASTLE (Royal Australian Air Force, Navstar GPS Joint Program Office, Los Angeles Air Force Station, CA) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 122-124.

Attention is given to trials conducted by the Australian Defence Force to assess Navstar GPS user equipment. Two low-dynamic single channel receivers and two high-dynamic five channel receivers were used. The Navy Sea King helicopter trial, the FFG-7 trial, and differential GPS trials are discussed in detail. It is concluded that GPS can provide highly accurate navigation data to military and civilian users alike. K.K.

#### A87-19363#

##### DIFFSTAR - A CONCEPT FOR DIFFERENTIAL GPS IN NORTHERN NORWAY

H. FJEREIDE (A/S Kongsberg Vaapenfabrikk, Norway) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 125-130.

The development of a real-time differential GPS system is traced. The carrier of the differential message is the Consol navigation system which has a range capability of about 1000 km from the reference station. The primary user of the differential system will be the oil industry since it has a high accuracy requirement. K.K.

#### A87-19364#

##### THE STANDARD INERTIAL NAVIGATION SET - A DECADE OF PROGRESS

J. LEWI (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 131-135.

The 1975 U.S. Air Force decision to institute a policy to develop a Standard Inertial Navigation Set has led to three competitions for such systems. The resulting systems have an extremely versatile set of input-output capabilities, both analog and digital. Allowances have been made for new technology and a single agency has been deemed responsible for the development, qualification, and acquisition of these standard systems. K.K.

**A87-19365#**

## **STANDARD INTEGRATION FILTER (SIF) STATE SPECIFICATION AND ACCURACY PROJECTIONS**

W. R. GRAHAM (Analytic Sciences Corp., Reading, MA) and G. R. JOHNSTON (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 136-142. refs

A 27-state three-axis Standard Integration Filter (SIF) model, formulated to integrate external navigation aids with all variants of the Air Force Standard INS, is presented. Linear covariance analysis is employed to predict rms horizontal and vertical navigation errors for integrated systems composed of combinations of medium- or high-accuracy gimbaled or ring-laser gyro trapdown Standard INS variants and three navigation aids: Global Positioning System, Common Strategic Doppler Radar, and baro-altimeter. Projections are provided for several contrasting NAVAID suites and for missions over representative fighter and transport trajectories. Author

**A87-19408**

## **NOVEL ACCURACY AND RESOLUTION ALGORITHMS FOR THE THIRD GENERATION MTD**

E. L. COLE, M. J. HODGES, R. G. OLIVER, and A. C. SULLIVAN (Westinghouse Electric Corp., Baltimore, MD; FAA, Washington, DC) IN: National Radar Conference, Los Angeles, CA, March 12, 13, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 41-47. refs

Algorithms developed to perform centroiding and provide improved range and azimuth resolution of the ASR-9's Multiple Target Detector are described. The performance results of the algorithms in the ASR-9 are demonstrated using simulations. Methods of field test and evaluation are presented. I.S.

**A87-19415**

## **STATISTICAL CLASSIFICATION OF RADAR CLUTTER**

W. STEHWIEN and S. HAYKIN (McMaster University, Hamilton, Canada) IN: National Radar Conference, Los Angeles, CA, March 12, 13, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 101-106. refs

Recorded clutter data were classified into different classes, such as birds, aircraft, cars, ground, and storms, using the classifier described by Stehwien and Haykin (1984), which is based on maximum entropy spectral analysis method of Burg (1967). It is shown that the classifier identifies correctly the clutter type, with error rates ranging from 10 to less than 1 percent for dissimilar types. The classifier was also found to successfully assign undefined clutter types to their most closely related classes. I.S.

**N87-13426#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

## **CONSIDERATIONS ON MICROWAVE LANDING SYSTEM (MLS) APPROACH PATH INTERCEPTION PROCEDURES AND APPLICABLE TURN TECHNIQUES**

L. J. J. ERKELENS and T. H. M. HAGENBERG 15 Aug. 1986 32 p Presented at the International Seminar on the Microwave Landing System, Montreal, Canada, 3-4 Sep. 1985 (NLR-MP-85063-U; B8669794; ETN-86-98660) Avail: NTIS HC A03/MF A01

A fast-time computer was used to evaluate the predictability and logic of microwave landing system interception procedures and to evaluate the accuracy and complexity of the algorithms for various (open versus closed loop) turn techniques with related glide path definition. A real time (Boeing 747) flight simulation was carried out to further evaluate the interception procedures and most promising turn techniques resulting from the fast-time computer simulation. Results of the evaluation of the turn techniques as implemented in different flight director systems are presented. ESA

**N87-14308** Civil Aviation Authority, London (England). Air Traffic Control Evaluation Unit.

## **SURVEY OF TRACK KEEPING AND ALTITUDES ON HEATHROW AND GATWICK STANDARD INSTRUMENT DEPARTURE ROUTES**

C. K. TOWNEND Dec. 1984 82 p (CAA-PAPER-84018; ATCEU-511; ISBN-0-860-39-229-5; ETN-87-98596) Avail: Issuing Activity

Track keeping of aircraft departing from Heathrow and Gatwick airports in relation to the published Standard Instrument Departure Routes was studied. The variations in aircraft lateral displacements and altitude at specific distances along each route are shown. ESA

**N87-14309** Bundesanstalt fuer Flugsicherung, Frankfurt am Main (West Germany).

## **ACTIVITIES REPORT IN AIR TRAFFIC CONTROL Annual Report, 1985 [JAHRESBERICHT 1985]**

Jun. 1986 54 p In GERMAN (ETN-87-98861) Avail: Issuing Activity

Developments in the aircraft and navigation fields including flight safety, flight accidents, and information systems are summarized. ESA

**N87-14310\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

## **DEVELOPMENT OF A PORTABLE PRECISION LANDING SYSTEM**

T. J. DAVIS, G. R. CLARY, and S. L. MACDONALD (Sierra Nevada Corp., Reno) Jul. 1986 21 p (NASA-TM-88247; A-86227; NAS 1.15:88247) Avail: NTIS HC A02/MF A01 CSCL 76D

A portable, tactical approach guidance (PTAG) system, based on a novel, X-band, precision approach concept, was developed and flight tested as a part of NASA's Rotorcraft All-Weather Operations Research Program. The system is based on state-of-the-art X-band technology and digital processing techniques. The PTAG airborne hardware consists of an X-band receiver and a small microprocessor installed in conjunction with the aircraft instrument landing system (ILS) receiver. The microprocessor analyzes the X-band, PTAG pulses and outputs ILS compatible localizer and glide slope signals. The ground stations are inexpensive, portable units, each weighing less than 85 lb, including battery, that can be quickly deployed at a landing site. Results from the flight test program show that PTAG has a significant potential for providing tactical aircraft with low cost, portable, precision instrument approach capability. Author

# 05

## **AIRCRAFT DESIGN, TESTING AND PERFORMANCE**

Includes aircraft simulation technology.

**A87-16927#**

## **BOLT-ON STOL KIT**

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Sept. 1986, p. 18, 19.

It is presently noted that a 'jump strut' STOL landing gear system, which extends the landing gear struts to rotate the aircraft to maximum-lift angle of attack at lower speeds, allows tactical aircraft to leave the ground in 60 percent less distance, or, with a full length takeoff roll, to carry a 25 percent heavier payload. The jump struts under consideration are extended by means of a nitrogen-charged piston and cylinder. The modification of the X-29 experimental aircraft for further development of this STOL concept is under consideration. O.C.



**A87-16941****LIFE THREAT ASSESSMENT LOGIC FOR ADAPTIVE CONTROL OF THE CREST EJECTION SEAT**

A. K. TRIKHA (Boeing Military Airplane Co., Seattle, WA) SAFE Journal, vol. 16, Fall 1986, p. 6-10.

The implementation of a digital controller, selectable thrust rockets with thrust-vectoring capability, and various seat-mounted sensors on the Boeing CREST demonstration ejection seat allows it to be controlled in an adaptive manner, so that the desired performance is achieved at wide variations in ejection conditions. One of the key performance goals is to maximize the probability of the crewmember survival, without subjecting him to any unnecessary risk of sustaining serious injuries. This paper presents the life threat assessment logic, which was developed to quantify the threat to the seat occupant's life and to generate the corresponding commands for the seat controller. This logic allows the transition from high acceleration levels to low acceleration levels on a continuous basis, so that a crewmember is not subjected to an injury risk level higher than that necessary for survival.

Author

**A87-16962\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**RECENT DEVELOPMENTS IN THE DYNAMICS OF ADVANCED ROTOR SYSTEMS. II**

W. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) Vertica (ISSN 0360-5450), vol. 10, no. 2, 1986, p. 109-150. Previously announced in STAR as N85-28917. refs

The problems that have been encountered in the dynamics of advanced rotor systems are described. The methods for analyzing these problems are discussed, as are past solutions of the problems. To begin, the basic dynamic problems of rotors are discussed: aeroelastic stability, rotor and airframe loads, and aircraft vibration. Next, advanced topics that are the subject of current research are described: vibration control, dynamic inflow, finite element analyses, and composite materials. Finally, the dynamics of various rotorcraft configurations are considered: hingeless rotors, bearingless rotors, rotors with circulation control, coupled rotor/engine dynamics, articulated rotors, and tilting prop rotor aircraft.

G.L.C.

**A87-16963\*** Rensselaer Polytechnic Inst., Troy, N.Y.

**NONLINEAR FLEXURE AND TORSION OF ROTATING BEAMS, WITH APPLICATION TO HELICOPTER ROTOR BLADES. I - FORMULATION. II RESPONSE AND STABILITY RESULTS**

M. R. M. CRESPO DA SILVA (Rensselaer Polytechnic Institute, Troy, NY) and D. H. HODGES (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) Vertica (ISSN 0360-5450), vol. 10, no. 2, 1986, p. 151-169, 171-186. Army-supported research. refs (Contract NAG2-38)

The dynamic response and aeroelastic stability of rotating beams such as helicopter blades is investigated analytically. The Hamilton principle is used to formulate the equations of motion for extensional and inextensional beams with precone angles and variable pitch angles, taking higher-order nonlinearities into account. The derivation of the equations and their approximate solution by a Galerkin procedure are explained in detail, and numerical results of equilibrium solutions and stability analyses are presented graphically.

T.K.

**A87-16964****CRASH IMPACT BEHAVIOUR OF SIMULATED COMPOSITE AND ALUMINIUM HELICOPTER FUSELAGE ELEMENTS**

D. C. BANNERMAN and C. M. KINDERVATER (DFVLR, Institut fuer Bauweisen- und Konstruktionsforschung, Stuttgart, West Germany) Vertica (ISSN 0360-5450), vol. 10, no. 2, 1986, p. 201-211. refs

An experimental investigation was conducted to study the crash impact behavior of simple helicopter structural elements in order to provide some of the basic knowledge required for designing to crashworthiness specifications. Aluminum tubes of circular and square cross sections having thickness to diameter ratios between

0.01 and 0.10 as well as aluminum and composite beam sections of stringer stiffened and sandwich constructions were examined under quasi-static and impact conditions. Speeds at impact were varied up to 12.8 m/s in accordance with MIL-STD-1290. The basic energy absorption characteristics - crush load uniformity, specific energy, crush stroke efficiency and average crush stress - are discussed and compared. The influence of impact velocity along with failure modes and the effects of trigger mechanisms used to help initiate stable and efficient crushing actions are also discussed.

Author

**A87-16965****SOVIET AND U.S. WEIGHT-PREDICTION METHODS AS TOOLS IN HELICOPTER OPTIMIZATION**

R. A. SHINN (U.S. Army, Aviation Research and Development Command, Saint Louis, MO) and W. Z. STEPNIIEWSKI Vertica (ISSN 0360-5450), vol. 10, no. 2, 1986, p. 227-240. refs

The helicopter-weight-prediction schemes of Tishchenko et al. (1976), Davis and Wisniewski (1974), and Shinn (1981) are compared in computations for a 15-ton transport helicopter. The aim is to adjust disk loading, tip speed, and blade number to minimize the weight of blades, hubs, and hinges; fuselage; drive system; and flight controls. It is found that all three schemes predict minimum weight at 6 blades and tip speed 720 ft/s; but that the optimum disk loadings are 9.5 lb/sq ft for the method of Tishchenko et al. and 12 lb/sq ft for the other two.

T.K.

**A87-16974****MIRAGE 2000 AND F-16 - ONE PILOT FLIES THEM BOTH**

J. CLOSTERMANN Interavia (ISSN 0020-5168), vol. 41, Sept. 1986, p. 975, 976.

A comparative evaluation is made of the flight handling qualities, payload capabilities, range, and operational envelopes of the Mirage 2000 and F-16 fighter aircraft. Attention is given to the consequences for maneuvering flight and cruise range of varying engine efficiencies between the turbojet employed by the Mirage and the low bypass turbofan used by the F-16, which delivers greater overall thrust. An assessment is also made of the comparative merits of the two fighters' radar/weapon delivery systems and air-to-air and air-to-ground weapons.

O.C.

**A87-17119****ON DAMAGE TOLERANCE DESIGN OF FUSELAGE STRUCTURE (LONGITUDINAL CRACKS)**

P. M. TOOR (Bettis Atomic Power Laboratory, West Mifflin, PA) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 24, no. 6, 1986, p. 915-927. refs

Linear elastic fracture mechanics are applied to model the tolerance of the integrity of typical aircraft fuselage structures to longitudinal cracks. The thrust of the investigation is the identification of fail-safe fuselage structures for military aircraft. A model is defined for the stress intensity factor (K<sub>IC</sub>) of a plate undergoing plane stress. Account is taken of variations of K<sub>IC</sub> with plate thickness, plasticity, and the effects of curvature, strings and frames, load transfer, and biaxial loading. Techniques are discussed for selecting test locations on the structure, limiting the sizes of defects considered, setting the maximum load levels to be tested, evaluating potential critical crack paths, and establishing safety assessments based on the analytical results.

M.S.K.

**A87-17140#****PIPING RPVS ABOARD**

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, Nov. 1986, p. 12, 13.

The recovery of remotely-piloted vehicles (RPVs) for ship use is examined. The procedures for the on-deck recovery of small RPVs of approximately 30 lbs with a 9-foot span, the on-land recovery of a 250-lb, 10-foot-long and 14-foot-span RVP, and the in-water recovery of a proposed 1500-lb, 20-foot-long RVP are described. The composition and capabilities of these three types of RPVs are discussed.

I.F.



## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

**A87-17143\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **HOW DIFFERENT A MODERN SST WOULD BE**

C. DRIVER (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 24, Nov. 1986, p. 26-29.

The characteristics of a proposed SST are described. The proposed aircraft is to have two engines and an arrow-wing design, a passenger capacity of 250, and attain speeds of Mach 2.7. The low fineness ratio, low-aspect ratio wing planform, different engine nacelles location, and improved lift-to-drag ratio of the aircraft contribute to attaining an economical supersonic cruise. The proposed structural design and materials for the aircraft are examined; the material and design are to be applicable to high Mach and high temperature. Changes in the SST propulsion system, the nozzle designs, and landing and takeoff procedures to improve the operation of the aircraft are discussed. I.F.

**A87-17144#**

### **FLYING-WING SST FOR THE PACIFIC**

R. T. JONES Aerospace America (ISSN 0740-722X), vol. 24, Nov. 1986, p. 32, 33.

The benefits of an oblique-wing design for a SST are discussed. The flying wing would provide an improvement in the lift-to-drag ratio for cruise and subsonic maneuvering, an increase in passenger capacity, and automatic stability. Consideration is given to the leading-edge thrust of the oblique wing at supersonic speeds. I.F.

**A87-17416**

### **COCKPIT ADDED FOR EVALUATING HELICOPTER SYSTEMS**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Sept. 1986, p. 8-14.

An S-76 helicopter has been modified to serve as the 'Shadow' development testbed for cockpit automation and flight control technology. A single seat crew station cockpit has been mounted forward of the conventional helicopter cockpit, and its flight control system configured in such a way as to allow simulation of different aircraft designs' handling qualities. The flight control system is in addition designed to allow direct computer address during flight. O.C.

**A87-17718**

### **FLIGHT TESTING OF AIRCRAFT AND PROCESSING OF TEST RESULTS [LETNYE ISPYTANIYA SAMOLETOV I OBRABOTKA REZUL'TATOV ISPYTANII]**

I. M. PASHKOVSKII, V. A. LEONOV, and B. K. POPLAVSKII Moscow, Izdatel'stvo Mashinostroenie, 1985, 416 p. In Russian. refs

The book deals with the theoretical and practical aspects of the flight testing of aircraft and test data processing. Topics discussed include the theoretical principles of the flight testing of aircraft, preparation of the aircraft and of the crews for flight tests, special measurements and calibrations during flight testing, and methods for determining the principal performance and handling characteristics of aircraft. The discussion also covers in-flight studies of the critical regimes of state-of-the-art high-speed aircraft, deterministic and statistical processing of experimental data, and evaluation of parameters from flight test data. V.L.

**A87-17725**

### **FLIGHT TESTS OF LIFE-SUPPORT SYSTEMS AND SYSTEMS FOR THE PROTECTION OF ONBOARD EQUIPMENT AGAINST EXTERNAL FACTORS [LETNYE ISPYTANIYA SISTEM ZHIZNEOBESPECHENIYA I ZASHCHITY BORTOVOGO OBOURODOVANIYA OT VNESHNIKH VOZDEISTVII]**

IU. A. NAGAEV, R. D. ISKANDAROV, R. KH. TENISHEV, V. M. KOSTYLEV, and V. N. EVGENOV Moscow, Izdatel'stvo Mashinostroenie, 1985, 128 p. In Russian. refs

The present work describes a flight-test methodology for aircraft life-support systems and systems for the protection of the aircraft against external factors (e.g., air-conditioning, oxygen-supply, and antiicing systems). Consideration is given to the specific flight-test

techniques; the evaluation sequence of the agreement between test results and prescribed requirements and standards; and methods for assessing external factors acting on onboard equipment. Safety assurance for the flight tests is examined. B.J.

**A87-17876#**

### **F-20 EVOLUTION**

A. TITIRIGA, JR. and B. HUNT (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 21 p. (AIAA PAPER 86-2612)

An overview of the technical development of the F-20 multirole aircraft is presented in this paper, which summarizes the evolutionary project stages and advanced design studies preceding the initial aircraft configuration. The requirements for designed-in reliability and maintainability are presented, as are the design requirements and development testing for the digital, fully integrated avionics suite, with a federated architecture system for the allocation of processing tasks. Key features of the aerodynamic design, propulsion system, fixed geometry air induction system, flight control system, secondary power systems and airframe interfaces are described. Performance data for the production aircraft are included. Author

**A87-17877#**

### **X-29 ADVANCED TECHNOLOGY INTEGRATION FOR TOMORROW'S FIGHTER AIRCRAFT**

T. M. WEEKS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. (AIAA PAPER 86-2613)

The X-29 Advanced Technology Demonstrator program is underway and in flight status at NASA's Dryden Flight Research Facility. A set of advanced airframe technologies is being demonstrated for consideration by designers of tomorrow's combat aircraft. These technologies are described and preliminary quantitative results are discussed. These technologies are, furthermore, integrated with the X-29 airframe. Tomorrow's combat aircraft will require new, integrated technologies and will benefit from the X-29 integration experience base. The X-29 aircraft is being considered for several potential 'test bed' demonstrations of new equipment and airframe concepts and will serve well in this role to satisfy near term requirements. Author

**A87-17878\*#** Lockheed-Georgia Co., Marietta.

### **APPLICATION OF DECOMPOSITION TECHNIQUES TO THE PRELIMINARY DESIGN OF A TRANSPORT AIRCRAFT**

J. E. ROGAN, R. P. MCELVEEN, and M. A. KOLB (Lockheed-Georgia Co., Marietta) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. refs

(Contract NAS1-18068)

(AIAA PAPER 86-2617)

A multifaceted decomposition of a nonlinear constrained optimization problem describing the preliminary design process for a transport aircraft has been made. Flight dynamics, flexible aircraft loads and deformations, and preliminary structural design subproblems appear prominently in the decomposition. The use of design process decomposition for scheduling design projects, a new system integration approach to configuration control, and the application of object-centered programming to a new generation of design tools are discussed. Author

**A87-17879#**

### **THE DESIGN OF A SUPPORTABLE FIGHTER**

T. L. HARRELL (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 14 p. refs

(AIAA PAPER 86-2618)

The anticipated year-2000 threat environment for U.S. fighter forces is bringing about dramatic changes in operational requirements. The operational strategy for the year 2000 and

beyond focuses on reducing support structure vulnerability by emphasizing mobility, flexibility, and survivability. New airbase support concepts are required. The capability to maximize the use of dispersed operating locations by small, autonomous force units has been identified as key to combat survivability. From a design perspective, this means designing new levels of autonomy into fighter systems to make dispersed/austere basing operations practical and effective. The design requirements and desired configuration characteristics for a minimum-maintenance fighter will be presented. A configuration with these attributes will be discussed. Features that reduce maintenance time or eliminate required support equipment will be emphasized. The effect of utilizing 'modular' subsystems and structural concepts on vehicle supportability will be highlighted. Author

**A87-17882\*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

#### **INTEGRATED AERODYNAMIC/STRUCTURAL DESIGN OF A SAILPLANE WING**

B. GROSSMAN, Z. GURDAL, R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg), G. J. STRAUCH, and W. M. EPPARD AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. refs

(Contract NAG1-505; NAG1-603)

(AIAA PAPER 86-2623)

Using lifting-line theory and beam analysis, the geometry (planform and twist) and composite material structural sizes (skin thickness, spar cap, and web thickness) were designed for a sailplane wing, subject to both structural and aerodynamic constraints. For all elements, the integrated design (simultaneously designing the aerodynamics and the structure) was superior in terms of performance and weight to the sequential design (where the aerodynamic geometry is designed to maximize the performance, following which a structural/aeroelastic design minimizes the weight). Integrated designs produced less rigid, higher aspect ratio wings with favorable aerodynamic/structural interactions. R.R.

**A87-17885#**

#### **AERODYNAMIC - STRUCTURAL OPTIMIZATION OF POSITIVE/NEGATIVE STAGGER JOINED WING CONFIGURATIONS**

B. P. SELBERG and D. L. CRONIN (Missouri-Rolla, University, Rolla) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs (AIAA PAPER 86-2626)

Dual wing configurations attached at the tip are analyzed aerodynamically and structurally. Both a positive stagger, the Swept Forward-Swept Rearward (SFSR) configuration, and a negative stagger, the Wolkovitch Joined Wing (JW) configuration, were analyzed with a common fuselage, engine, payload, etc. Both configurations are analyzed with the goal of designing an optimum configuration subject to design constraints. Two-dimensional drag, three-dimensional drag, wing weights, wing deflections, and modal activity are among the factors discussed for both the JW and the SFSR configurations. Both configurations are compared for a typical cruise condition. Relative to the JW configuration, the SFSR configuration has better performance characteristics, lower drag characteristics, as well as marginally lower structural weight. Author

**A87-17889#**

#### **X-29 - MANAGING AN INTEGRATED ADVANCED TECHNOLOGY DESIGN**

G. L. SPACHT (Grumman Corp., Bethpage, NY) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 6 p. (AIAA PAPER 86-2630)

The X-29 is the fulfillment of a program initiated in 1976 to explore the aerodynamic advantages of the forward swept wing. The aircraft, however, is much more than a forward swept wing demonstrator. The X-29 is an integrated advanced technology

demonstrator incorporating eight advanced technologies in a single aircraft. The integrated aspect of the program cannot be over-emphasized because integration can be considered an additional technology that, if not successfully managed, could have endangered the entire program. The goal of the X-29 flight test program is to successfully demonstrate the performance of the integrated technology set in flight. This paper explains the philosophy of the technologies incorporated in the X-29 aircraft, the steps taken to reduce the risk of the inherently high risk program, and the benefits of the management approach as demonstrated by the flight test program. Author

**A87-17898#**

#### **CONFIGURATION DEVELOPMENT OF A TANDEM FAN V/STOL ASSAULT TRANSPORT**

T. D. KASTEN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. refs

(AIAA PAPER 86-2642)

An investigation of the configuration and performance characteristics of a V/STOL advanced tactical transport was conducted. A unique concept employing four upper surface tandem-fan engines was optimized to carry a 27,000 lb payload on a 950-n.mi. assault mission with numerous assault landings and the substantial low-altitude cruise flight with a continuous 3g-weave flight path. A tactical deployment mission with a 36,000-lb payload was also investigated. Sizing parameters including wing loading thrust loading, and planform characteristics were varied to determine iterated configuration effects. Fixed weight and drag coefficients were also determined. Author

**A87-17901#**

#### **VTOL OPERATIONAL CONSIDERATIONS AND THEIR IMPACT ON FUTURE MILITARY DESIGN REQUIREMENTS**

D. P. SCHRAGE and S. A. MEYER (Georgia Institute of Technology, Atlanta) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. refs (AIAA PAPER 86-2649)

Attention is given to VTOL operational considerations and their impact on future military design requirements. Particular emphasis is placed on: (1) the need for high thrust-to-weight ratio engines, (2) possible effects on the environment, personnel or aircraft itself which can interfere with mission accomplishment, and (3) transition-related matters. It is believed that such production systems as the V-22 Osprey tilt rotor and the x-wing signify that VTOL aircraft are alive and well. K.K.

**A87-17906#**

#### **TACTICAL AIRCRAFT PAYOFFS FOR ADVANCED EXHAUST NOZZLES**

C. J. CALLAHAN (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 17 p. refs (Contract F33615-79-C-3009)

(AIAA PAPER 86-2660)

Tactical aircraft payoffs for advanced exhaust nozzles were examined in a broad analytical study which was conducted as part of a USAF sponsored program. The analytical effort was thus supported by a large data base acquired through major wind tunnel tests conducted during the principal program. Central to the analytical study effort were four different advanced exhaust nozzle configurations which were alternately installed in a representative fighter/penetrator-type baseline aircraft configuration. Analytical study results emphasize important advanced exhaust nozzle benefits to tactical aircraft field performance and flight performance. Emphasis was placed on takeoff and landing distances for STOL operation, preservation of mission capabilities, and inflight maneuvering for tactical advantage. The concomitant demands on aircraft size, or equivalently TOGW, served as the corollary nozzle design and installation penalty parameter for the study. Author

## A87-17913#

### ADVANCED TECHNOLOGY TACTICAL TRANSPORT

J. R. SNYDER (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. refs (AIAA PAPER 86-2668)

This paper describes a novel approach to conducting a short term design feasibility study of an airplane that could satisfy a unique set of design requirements. The Advanced Technology Tactical Transport (ATTI) is an aeronautical system for satisfying some tactical missions. The problem was to define a representative configuration geometry for the aircraft, and to ascertain if the design mission could be accomplished within a specified target gross weight. Technology levels needed to meet the target gross weight were also to be identified. Study results show that a conventional aluminum structure airplane could meet the mission requirements. A powered lift system was required, and was provided on the airplane by the interaction of the propeller slipstream and the flap system. If advanced materials were used in the airframe, a modest reduction in airplane gross weight could be removed. Author

A87-17915\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### PERFORMANCE STUDIES ON THE APPLICATION OF FOUR-ENGINE AND TWO-ENGINE USB PROPULSIVE LIFT TO THE E-2C AIRCRAFT

D. W. RIDDLE and V. C. STEVENS (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 13 p. refs (AIAA PAPER 86-2674)

A study has been completed of the performance benefits to be derived from applying advanced upper-surface blowing (USB) propulsive-lift technology to the E-2C aircraft. The results of comparing four-engine with two-engine USB configurations are discussed, and engine sizing and aerodynamic/structural considerations pertaining to the E-2C/USB modification are examined. The effects of the modification on performance are described in detail with regard to takeoff distance and landing distance estimation in free-deck operations, operations using catapult and arresting gear, ceiling and radar surveillance missions, and range and endurance capability. C.D.

## A87-17916#

### SEA-BASED MULTIMISSILE STOVL APPLICATION OF AN AIBF/VT HYBRID POWERED-LIFT SYSTEM

W. L. POSNETT, III (U.S. Navy, Naval Air Rework Facility, Pensacola, FL), Y.-T. CHIN (Lockheed-California Co., Burbank), and M. F. PLATZER (U.S. Naval Postgraduate School, Monterey, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs (AIAA PAPER 86-2675)

Short Takeoff and Vertical Landing (STOVL) aircraft are options for future replacement of sea-based conventional Takeoff and Landing (CTOL) aircraft. A conceptual design study was conducted to evaluate the feasibility of a minimum-cost modification of the S-3A airframe to an S-3 STOVL configuration. The STOVL concept is based on using four TF34 turbofan engines and application of the Advanced Internally Blown Jet Flap/Vectored Thrust hybrid power-lift system. The S-3 STOVL deck performance estimates are presented along with mission performance comparisons with four CTOL aircraft. Author

## A87-17917#

### MARINIZED APACHE/AN ENGINEERING CHALLENGE

P. J. F. OREILLY (McDonnell Douglas Helicopter Co., Mesa, AZ) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. (AIAA PAPER 86-2676)

The paper discusses the engineering design and analysis work done to marinize the Apache attack helicopter. Studies of the following aircraft systems are discussed: main rotor blade folding, landing gears, EMC/EMI hardening, air-to-air missiles, rotor brake

improvements, anti-ship missiles, search and track radar and aerial refueling. Major factors in the studies were ship compatibility, cost (initial and life-cycle), weight, performance and integrated logistic support. Author

## A87-17919#

### AERODYNAMIC DEVELOPMENT OF THE V-22 TILT ROTOR

H. ROSENSTEIN and R. CLARK (Boeing Vertol Co., Philadelphia, PA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 16 p. refs (AIAA PAPER 86-2678)

The aerodynamic development of the V-22 is described. Operational constraints and design requirements to meet future threats impose a significant challenge on the V-22 aerodynamic configuration. A comprehensive program of wind tunnel testing, flight simulation and use of mockups was established to acquire the information necessary to make proper design decisions while reducing overall program risk. The aerodynamic development of the major components including rotor, wing, fuselage/sponson, empennage, and engine inlets is discussed, along with the aerodynamic characteristics based on extensive testing and test/theory correlation. A summary of V-22 performance is then presented. Author

## A87-17921#

### VALIDATION OF A FIGHTER AIRCRAFT SIMULATION USING HIGH ANGLE-OF-ATTACK FLIGHT TEST DATA

R. A. HESS (Systems Control Technology, Inc., Lexington Park, MD) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. refs (AIAA PAPER 86-2681)

Presented in this paper are results which demonstrate a methodology using flight test data to improve an aircraft simulation model. A principal components regression analysis is used to identify aerodynamic stability and control parameters from flight test data. The identified parameters are compared to those in an existing wind-tunnel based simulation. This comparison pinpoints possible inaccuracies in the existing simulation. Implementation of the flight identified parameters into the simulation is shown to improve the prediction capability of the simulation, and hence, a higher fidelity aircraft aerodynamic model is formed. Author

## A87-17925#

### ASSESSING TECHNOLOGIES FOR FIGHTER AIRCRAFT PREPLANNED-PRODUCT IMPROVEMENT AND RETROFIT

J. V. KITOWSKI (General Dynamics Corp., Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs (AIAA PAPER 86-2688)

In order for current production and inventory aircraft to counter the projected threat in the 1990-2000 time frame and beyond, government and industry must identify, analyze, budget, and plan for cost-effective and affordable enhancements. An assessment process has been developed for planners to facilitate achievement of these essential upgrades. Key elements of the process are identifying mission requirements, determining baseline capability, performing technology survey, conducting configuration pre-design, and assessing mission performance/cost-effectiveness. These elements and the application of the process to two force-improvement problems are treated in this paper. Author

## A87-17929#

### TRANSMISSION FATIGUE LIFE ESTIMATION FOR SEA KING HELICOPTERS OPERATED BY THE ROYAL AUSTRALIAN NAVY

K. F. FRASER and C. N. KING (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs (AIAA PAPER 86-2692)

Prototype equipment developed at the Aeronautical Research Laboratories has been installed in two Royal Australian Navy Sea King helicopters to estimate the fatigue life usage of critical gears

in the main rotor gear box under Australian operating conditions. The equipment is capable of monitoring actual life usage of individual gear boxes in 'damage' or 'life fraction' terms. Some 479 hours of in-flight load data covering 227 flights and 8 main sortie types have been accumulated. These data have been analyzed and it has been concluded that for practical purposes, the lives of the gears in the main rotor gear box are not limited by fatigue. Author

**A87-17930#**  
**AERODYNAMIC DESIGN OF LOW-SPEED AIRCRAFT WITH A NASA FUSELAGE/WAKE-PROPELLER CONFIGURATION**

F. R. GOLDSCHMIED AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 19 p. refs  
 (AIAA PAPER 86-2693)

A brief parametric study has been carried out on the application of a NASA axisymmetric fuselage/wake-propeller configuration to low-speed general-aviation aircraft with conventional NACA wings. The experimental propulsive efficiency of the NASA configuration goes from 103 percent for the bare fuselage to a range between 96 percent and 85 percent for the aircraft. The aerodynamic efficiency index ranges from 17.95 to 11.47, while that for conventional aircraft ranges from 7.95 to 5.00, as shown by a survey of 76 general aviation and sport aircraft. A 50 percent power reduction, for the same gross weight and speed, is a very practical possibility. Author

**A87-17933#**  
**OPTIMISATION OF THE CONCEPTUAL DESIGN AND MISSION PROFILES OF SHORT-HAUL AIRCRAFT**

D. SIMOS and L. R. JENKINSON (Loughborough University of Technology, England) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs  
 (AIAA PAPER 86-2696)

This paper outlines a method of sizing new short-haul commuter aircraft by conducting a flight profile optimization procedure in parallel with the optimization of the major design parameters. Minimum-fuel, minimum-cost, or minimum-mass aircraft can be designed for a given mission, which would be optimally flown. The method is capable of handling both equality and inequality constraints which may relate to either design boundaries or operational flight restrictions. Results of some case studies are presented. It is found that the impact of operational limitations, particularly restrictions in the rate of descent, can have a significant effect on the value of the objective function. The penalty may be as large as that caused by design requirements such as minimum field performance. Author

**A87-17947#**  
**ADVANCED TRAINER AIRCRAFT DESIGN FOR FIGHTER-ATTACK-RECCE ROLES**

T. C. DUDLEY, SR. (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. refs  
 (AIAA PAPER 86-2729)

Aircraft design syntheses and analyses have been conducted by the U.S. Air Force in order to identify the most attractive features of next-generation trainers for fighter-attack-reconnaissance (FAR) aircraft pilots. After a preliminary study of existing FAR aircraft and trainers, attention was given to pertinent design variables and a range of their values for parametric analyses. Wing loading, engine thrust/aircraft gross weight ratio, and wing aspect ratio and sweep, were taken as the primary design variables. O.C.

**A87-17950#**  
**MAGNA NONLINEAR FINITE ELEMENT ANALYSIS OF T-46 AIRCRAFT WINDSHIELD BIRD IMPACT**

R. E. MCCARTY, M. G. GRAN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and M. J. BARUCH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH; Fairchild Republic Co., Farmingdale, NY) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs  
 (AIAA PAPER 86-2732)

The Air Force and Fairchild Republic Company agreed to use the MAGNA nonlinear finite element analysis computer program to reduce the number of full scale bird impact tests being conducted in support of windshield system development for the new T-46A primary trainer aircraft. It was planned to use MAGNA to simulate the impact of a 4 lb bird at 250 knots on the centerline of the windshield, 10 inches forward of the windshield bow structure. These analysis results, when combined with a judgmental evaluation of previously unsuccessful test results at higher speeds, would serve to show that windshield impact at a critical location of a bird weighing up to 4 lb would not result in crew injury or loss of the aircraft during the first flight (planned for up to 250 knots) and initial phases of flight testing. The computer simulation was successfully accomplished in time, and it indicated that the windshield assembly would defeat the bird impact involved. As a result, the windshield configuration selected for the first several flights was flown without having been subjected to full scale bird impact testing at 250 knots. Author

**A87-17954#**  
**MAXIMUM SIZE OF A NONRIGID AIRSHIP**

J. E. HOUMARD (Goodyear Aerospace Corp., Akron, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs  
 (AIAA PAPER 86-2736)

The fabric seam strength of the pressure hull and the maximum limit design pressure are the primary technical constraints upon the maximum size of a nonrigid airship. The maximum limit design pressure is a function of the required operating pressure and increased pressure due to gas valve performance when ascending through pressure height. The operating pressure is usually dictated by the maximum design bending moment. The values of these parameters used to arrive at the maximum airship size are discussed. A discussion of fabrics constructed of aramid cloths as compared to those of polyester cloths is presented. It is concluded that aramid is not acceptable for use in the pressure hull of a nonrigid airship. Author

**A87-17955#**  
**TEST FLYING THE CYCLO-PLANE 'PROOF-OF-CONCEPT' EXPERIMENTAL MODEL N240AL**

J. J. MORRIS (Aerolift, Inc., Tillamook, OR) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 12 p.  
 (AIAA PAPER 86-2737)

The objective of this presentation is to present the results of recent flight testing of the proof-of-concept model Cyclo-Crane. The presentation includes: a description of the aircraft and its flight controls; flight testing background; the Cyclo-Crane dynamic simulation model; problems encountered and results obtained from flight testing; and a discussion of the next generation system. Author

**A87-17956#**  
**PERFORMANCE CHARACTERISTICS OF A 25 TON PAYLOAD AGILIFTER**

W. T. GRADY (Aerial Mobility, Inc., Dayton, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. refs  
 (AIAA PAPER 86-2738)

A new class of heavy lift aircraft has recently emerged. Called 'Hybrid Airships', they combine Lighter-Than-Air Hulls and Heavier-Than-Air vertical lift technology. These hybrid airship

concepts offer Vertical Takeoff and Landing opportunities greater than are possible with Heavier-Than-Air technologies at the same state-of-the-art. This paper describes the Aerial Mobility Incorporated (AMI) Agilifter hybrid airship concept which offers unique maneuverability and design flexibility, in addition to high payload potential. Design features, performance characteristics, productivity, dynamics and cost of a 25 ton payload Agilifter are discussed. The challenges and opportunities which hybrid airships present to the designer are emphasized. Author

## A87-17957#

### THE OTHER HYBRID AIRSHIP DEVELOPMENTS

D. L. QUAM (QuamAero Research Inc., Dayton, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. refs (AIAA PAPER 86-2740)

Examples of two general types of hybrid airships are described. These two types are the quad-rotor and the rotating sphere. The descriptions include three-view drawings, tables of specifications and some estimated performance data. In addition, the basic control mechanisms are described. Author

## A87-17958#

### PERFORMANCE PREDICTION AND FLIGHT EVALUATION OF HYBRID HEAVY LIFT SYSTEMS

B. M. PERSHING (Aerospace Corp., El Segundo, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 26 p. refs (Contract USDA-53-94H1-2-9051N; USDA-53-04H1-2-8747N) (AIAA PAPER 86-2741)

Procedures for predicting the performance of generic multi-rotor and cyclo-rotor hybrid heavy lift systems are described. The procedures for multi-rotor systems are shown to be similar to those for helicopters, while cyclo-rotor systems require the simultaneous solution of their thrust and rotational moment equations. Comparisons are made of the predicted cyclo-rotor wing control characteristics with available test data. The predicted performance of the Piasecki (PiA) Heli-Stat and AeroLift Cyclo-Crane is presented, and the results of an economic evaluation of second-generation production design hybrid heavy lift systems are summarized. Author

A87-17963\*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

### WRIGHT BROTHERS LECTURESHIP IN AERONAUTICS: EXPERIENCE WITH HIMAT REMOTELY PILOTED RESEARCH VEHICLE - AN ALTERNATE FLIGHT TEST APPROACH

D. A. DEETS (NASA, Flight Research Center, Edwards, CA) and L. E. BROWN (Rockwell International Corp., North American Aircraft Operations Div., El Segundo, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 19 p. refs (AIAA PAPER 86-2754)

The highly maneuverable aircraft technology (HiMAT) program explored the various and complex interactions of advanced technologies, such as aeroelastic tailoring, close-coupled canard, and relaxed static stability. A 0.44-subscale remotely piloted research vehicle (RPRV) of a hypothetical fighter airplane was designed and flight-tested to determine the effects of these interactions and to define the design techniques appropriate for advanced fighter technologies. Flexibility and high maneuverability were provided by flight control laws implemented in ground-based computers and telemetered to the vehicle control system during flight tests. The high quality of the flight-measured data and their close correlation with the analytical design modeling proved that the RPRV is a viable and cost-effective tool for developing aerodynamic, structure, and control law requirements for highly maneuverable fighter airplanes of the future. Author

## A87-18116

### A NEW TECHNOLOGY IN ENERGY-EFFICIENT ELECTRICALLY DRIVEN AIRCRAFT ENVIRONMENTAL CONTROL SYSTEMS

W. W. CLOUD (Lockheed-California Co., Burbank, CA), J. E. MCNAMARA (U.S. Navy, Naval Air Development Center, Warminster, PA), and D. B. WIGMORE (Sunstrand Corp., Rockford, IL) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3. Washington, DC, American Chemical Society, 1986, p. 1696-1702.

In this paper, the theory of nonazeotropic refrigerants and their application in airborne electric vapor-cycle environmental control systems is reviewed, along with the basic dependencies on air vehicle Mach number and heat sink characteristics. Differences in cycle enthalpies of nonazeotropic binary and monorefrigerants accounting for improved COP are identified. Data obtained from laboratory testing are summarized and compared with theoretical predictions. Problems in the practical application of vapor-cycle cooling systems in aircraft including the effects of acceleration, negative gravity, and inverted operation are discussed; and areas of further investigation are indicated. Author

## A87-18450

### AEROSPATIALE DESIGN BUREAUS. II - HELICOPTERS FOR THE YEAR 2000

C. FIORI Revue Aerospatiale (ISSN 0065-3780), Sept. 1986, p. 38-43. In English and French.

The operations, equipment and design projects and management of the Aerospatiale Marignane helicopter design division are described. Design teams which include engineers, designers, manufacturing, flight-test and quality control personnel are established for each new design project. All members participate and interact throughout aircraft development. The organizational structure was used with the Super Frelo, the Gazelle, and the Dauphin in the 1960s, and led to the development of the all-composite Starflex rotor in the 1970s, with the benefits being exploited for the Super Puma, the Dauphin 2 SA365 and Ecureuil 2 helicopters. The engineering teams are continuously devising new programs for performing numerical analysis and design routines for all components and analyses of helicopters. M.S.K.

## A87-18511

### VULNERABILITY AND SURVIVABILITY OF FLIGHT CONTROL ACTUATORS ON HELICOPTERS

B. E. RICKETTS (Dowty Boulton Paul, Ltd., Wolverhampton, England) Vertiflite (ISSN 0042-4455), vol. 32, Sept.-Oct. 1986, p. 26-28.

A twin-engine helicopter designed to operate under all-weather conditions is examined. The flight control system of the helicopter, which includes fly-by-wire and manual modes, assures control of the helicopter in case of double failure. The interaction between the pedals, lateral and longitudinal cyclic stick, and collective lever of the helicopter is studied; composite materials and rotary variable development transfusers are utilized in the design of the flight controls. The use of redundant control modes to minimize the effects of ballistic damage on the rotor actuators is discussed; the techniques and components utilized to prevent damage to the actuators are described. I.F.

## A87-18526#

### A STUDY OF THE ROTOR WAKE IN NAP-OF-THE-EARTH

C. HE and Z. GAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Aug. 1986, p. 325-331. In Chinese, with abstract in English. refs

In this paper an investigation of the ground vortex, a significant aerodynamic phenomenon in rotor aerodynamics on the nap-of-the-earth, is carried out. Based on the analysis of the rotor wake near the ground, a theoretical method, including the analytical model, the formulas and the computer program, has been established. By using a free wake model, with the ground vortex taken into account, the distribution of induced inflow at the rotor disk is also calculated. All computational results are compared

with available experimental data and found to be in good agreement. Author

**A87-18530#**

**A MATHEMATICAL MODEL FOR RELIABILITY ANALYSIS OF AIRCRAFT STRUCTURE**

D. ZHU (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Aug. 1986, p. 354-362. In Chinese, with abstract in English. refs

This paper presents a set of fundamental equations for reliability analysis of aircraft structures. For a single-critical-point structure, it considers the following factors: the static strength of the structure, initial crack, the residual strength of the structure, the statistical distribution of the load, the probability of crack detection, the communication of damage among fleets, etc. Based on this mathematical model, the influence of the various factors on reliability can be analyzed quantitatively, and the various criteria for fatigue design of an aircraft structure can be evaluated from the point of view of reliability. Author

**A87-18644**

**FLYING DASSAULT'S BIG BIRD**

H. HOPKINS Flight International (ISSN 0015-3710), vol. 130, Sept. 20, 1986, p. 38-42.

The design of the Falcon 900 which has a range of 4000 n. mi. and is fabricated from carbon and aramid composites is examined. The characteristics of the F900 and the F50 are compared. The cockpit, avionics, electronic flight instruments, engine, warning system, steering, and damage tolerance requirements of the F900 are described. Considerations are also given to the passenger cabin, fuel tanks, hydraulic and electrical systems, and the airbrakes of the F900. The operation of the aircraft is discussed. I.F.

**A87-19202**

**ROTOR-FUSELAGE COUPLING BY IMPEDANCE**

R. GABEL and V. SANKEWITSCH (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 1-11. refs

Vibratory rotor loads have been customarily calculated without hub impedance considerations and applied to the fuselage to obtain forced vibration. It is now being recognized throughout the industry that this simplistic approach is not correct, and math models with rotor fuselage coupling are required. The coupling method in development uses a feature of an already developed rotor analysis program which allows harmonic displacement of the hub and calculates the resulting effect on vibratory hub loads. A rotor impedance matrix is constructed by using this feature and a fuselage impedance matrix is obtained from a shake test or a finite element analysis. Coupling these rotor and fuselage impedance matrix equations leads to a set of rotor forces that include hub motion feedback. Analytical results are derived for a wind tunnel model and compared to test data. Coupled results differ significantly from those obtained without coupling. The analysis indicates that mechanical impedance effects dominate over aerodynamic effects for the wind tunnel model. Author

**A87-19203**

**ROTOR LOAD CORRELATION WITH THE A.S.P. BLADE**

R. E. HANSFORD (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 13-26. Research supported by the Ministry of Defence (Procurement Executive). refs

A new composite blade has been designed to improve high speed performance using advanced multiprofile sections and a swept tip. Flight test results are compared with standard blade measurements to analyse the influence of the new design on performance, rotor loads and aircraft vibration. Correlations are presented between measured bending moment distributions and theoretical rotor load predictions. The analytical model is used in

gaining insight to explain the different structural load characteristics of the two blades. In particular, the aeroelastic design features of the advanced blade are discussed in relation to the mechanisms responsible for the significant reduction in vibration that was achieved. Author

**A87-19204**

**APPLICATION OF DESIGN OPTIMIZATION TECHNIQUES TO ROTOR DYNAMICS PROBLEMS**

M. W. DAVIS and W. H. WELLER (United Technologies Research Center, East Hartford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 27-44. refs

Optimization techniques have been applied to various rotor dynamics problems to gain insight into the design process, project potential design benefits, and evaluate alternative problem formulations and solution strategies. A constrained optimization program was linked to a coupled-mode eigenvalue analysis to achieve a closed-loop computer program for optimizing blade dynamic characteristics. Analytical studies have been performed on a series of problems related to maximizing bearingless rotor inplane structural damping, placing blade natural frequencies, minimizing hub vibratory shears, and minimizing rotor modal vibration indices. These examples are representative of a hierarchy of optimization problems from relatively simple to complex, involving nonlinearities, multiple design criteria, multicomponent objective functions, and large numbers of design variables. The relative merits of alternative optimization algorithms and problems formulations are compared. Strategies to improve the efficiency and reliability of problem solution are discussed. Author

**A87-19205\* Bell Helicopter Co., Fort Worth, Tex.**

**AH-1G FLIGHT VIBRATION CORRELATION USING NASTRAN AND THE C81 ROTOR/AIRFRAME COUPLED ANALYSIS**

R. V. DOMPKA and J. J. CORRIGAN (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 45-61. refs

(Contract NAS1-17496)

Analytical results are presented bearing on the accuracy of state-of-the-art NASTRAN FEM modeling techniques and rotor/airframe coupling methods for the prediction of flight vibrations; these results have been studied by NASA and industry experts in order to ensure scientific control of the analysis/correlation exercise. The rotor loads predicted by the dynamically coupled rotor/airframe analysis showed good agreement between calculated and experimental blade loads, as did the predominant excitation frequency vibration levels predicted by NASTRAN. O.C.

**A87-19206**

**USE OF HIERARCHICAL ELASTIC BLADE EQUATIONS AND AUTOMATIC TRIM FOR HELICOPTER VIBRATION ANALYSIS**

S. N. KARUNAMOORTHY (Saint Louis University, Cahokia, IL) and D. A. PETERS (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 63-79. refs (Contract DAAG29-80-C-0092; DAAG29-85-K-0228)

The mathematical model used in the present unified approach to obtaining elastic helicopter blade equations in forward flight, during which the blade undergoes flap, lag, and torsional motions, employs a tensor method for strain components, a curvilinear coordinate system, a consistent ordering scheme, and an optimized automatic controller for trim settings. The hierarchical nature of the elastic blade equations opens the possibility of reducing them to various orders. A novel family of orthogonal polynomials is developed in order to apply a Galerkin time-history solution. O.C.



A87-19207

**CALCULATED AND MEASURED BLADE STRUCTURAL RESPONSE ON A FULL-SCALE ROTOR**

J. ESCULIER (Service Technique des Programmes Aeronautiques, Departement des Helicopteres, Paris, France) and W. G. BOUSMAN (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 81-110. refs

In the present consideration of the restricted problem of bending moment response of a full scale helicopter rotor's response to measured airloads, data are used from separate tests of an articulated rotor in flight and in a wind tunnel, and linear equations are used to represent blade mass and structure. By comparing the calculated blade-bending and torsional moment response with measurement, the adequacy of the structural model for vibratory load calculation is assessed. O.C.

A87-19208\* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AUTOMATED TUNING OF AIRFRAME VIBRATION BY STRUCTURAL OPTIMIZATION**

H. MIURA and M. CHARGIN (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 111-120. refs

Numerical optimization techniques are used to modify the dynamic response at a specified point(s) of a helicopter airframe structure due to a steady state narrow band excitation. Calculation of steady state vibration amplitude is reduced to the solution of linear equations with complex coefficients. The sensitivity of the dynamic amplitudes with respect to the structural parameter perturbations can be computed with the same technique as the one used in the static displacement sensitivity without requiring eigenvector sensitivity. Approximate models for critical structural responses are created based on the sensitivity data to reduce the amount of computational effort and to enable the design of structures of practical scale and complexity. This approach is general in that it accommodates static, dynamic, and frequency constraints simultaneously as long as their computational models are available. It can be used in optimizing mass distribution as well as stiffness modifications of practical structures. Author

A87-19209

**APPLICATIONS OF OPERATIONAL ANALYSIS TO THE PRELIMINARY DESIGN PROCESS**

M. DINNEEN (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) and P. DONNELLY (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 121-127.

Operational analysis can be an effective tool in the overall development process of a new helicopter by providing a link between the engineering design process and the military employment of the aircraft. By analyzing the capability of the aircraft in the appropriate scenarios, operational analysis can be used to define and understand requirements, support design tradeoffs, and ensure that design decisions maximize the military worth of the aircraft. The key requirements for such analyses are that they focus on the appropriate operational issues and that they provide results in a format that can be translated into basic aircraft design parameters. This ensures that the information can be readily understood and used by the design team. Author

A87-19222

**WIND TUNNEL TEST OF A PRESSURE INSTRUMENTED MODEL SCALE ADVANCED ROTOR**

J. COWAN, L. DADONE, and S. GANGWANI (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 217-229. refs

Wind tunnel airloads and performance measurements at high speeds have been conducted for a four-blade, 10-ft diameter, pressure gage-instrumented model helicopter rotor, two of whose blades were instrumented to obtain complete chordwise pressure distributions at six spanwise stations, while a third was equipped with leading edge pressure gages and the fourth carried strain gages to quantify chord and flap bending and torsion loads. The measured airloads have been correlated with detailed airload predictions calculated by means of two new transonic analysis codes. O.C.

A87-19227

**CORRELATION OF ACOUSTIC EMISSION AND STRAIN/DEFLECTION MEASUREMENT DURING COMPOSITE AIRFRAME STATIC TESTS**

J. P. PERSCHBACHER and W. C. BOYCE (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 315-325. refs

Acoustic emission (AE) improves detection, location, and characterization of damage during ultimate load testing of composite airframe structure. The AE system hardware and software is described, along with the criteria used to determine the placement of the transducers. The ability of the system to detect, locate, and to some extent characterize composite AE events is shown with specific examples from airframe static test programs. AE count rates are shown to correlate with load/strain and load/deflection nonlinearities during significant structural damage (cracks, delaminations). Author

A87-19228

**RESULTS OF THE V-22 PRELIMINARY DESIGN WING TEST PROGRAM**

C. A. SPRANGERS and M. K. STEVENSON (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 327-338.

As part of the V-22 preliminary design effort, wing torque box structures were designed, built, and tested to further the development of the full-scale-development carbon/epoxy composite wing. A wingtip section and a full-span wing torque box were the two major test items developed. Vibration, stiffness, and static strength tests were conducted on the wingtip box while stiffness and strength tests were conducted on the wing torque box. Good correlation was found between the analytical model and the test results leading to increased confidence in the analytical methods used to design the full-scale-development wing torque box. K.K.

A87-19230

**DESIGN AND STRUCTURAL FEATURES OF THE SH-2F COMPOSITE MAIN ROTOR BLADE**

W. F. ALEX and G. A. MCCOUBREY (Kaman Aerospace Corp., Bloomfield, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 345-359.

Kaman Aerospace Corporation has designed and currently is qualifying a composite main rotor blade assembly for the SH-2F Seasprite helicopter which is presently operating in U.S. Naval service. The composite blade spar is constructed to incorporate, as its major structural feature, a continuous load path of longitudinal and helical wound high strength glass fibers from blade root to tip. This paper summarizes the design and structural features of

the composite blade, servoflap, and longitudinal control rod employed in the blade assembly as well as the methods used in their manufacture. Author

**A87-19231****DESIGN AND DEVELOPMENT OF A COMPOSITE ROTOR HEAD**

E. SCHNEIDER, R. C. CHILDS, and F. MCARDLE (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 361-368.

The design of a low-weight, low drag, and minimum maintenance composite articulated rotor head involves the use of a laminated composite material as much as possible. In particular, the present study reveals that unidirectional composite straps can be effectively used as the primary structural elements in a rotor head, and that the use of cross-ply reinforcements around holes in straps permits load transfer through bolted joints. It is noted that interlaminar shear and interlaminar tension stresses provide the biggest challenge in establishing a structurally adequate configuration.

K.K.

**A87-19232****COMPOSITE APPLICATIONS IN THE DRIVE SYSTEM**

H. FAUST and J. MACK (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 369-374.

Attention is given to the design, fabrication, and testing of Model 360 major dynamic system components constructed from fiberglass/epoxy and graphite/epoxy composites. The use of composites can lead to a 20 percent weight reduction, as well as to the ability to selectively stiffen structural load paths and increase damage tolerance. It is believed that techniques aimed at reducing fabrication cost must be developed so that these advantages can be fully reaped.

K.K.

**A87-19234****AH-64A APACHE HELICOPTER - RELIABILITY, AVAILABILITY, MAINTAINABILITY/LOGISTICS RAM/LOG DATA SYSTEM**

H. E. POHLENZ (McDonnell Douglas Helicopter Co., Systems Engineering Dept., Culver City, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 389-397.

A U.S. Army-developed Reliability, Availability, Maintainability/Logistics (RAM/Log) data processing system was implemented during the initial AH-64A Apache Research and Development flight test program at McDonnell Douglas Helicopter company and has continued in operation through the first three years of the Apache Production Program. This RAM/Log data system has provided accurate and timely information required for design and product support improvements throughout its operation on the Apache Helicopter programs. This paper describes the basic RAM/Log data processing system operations and its overall capabilities. In addition, specific Apache Helicopter Program systems applications for Design Improvement and for Fault Detection/Location System (FD/LS) performance verification are discussed. An overall RAM/Log data systems evaluation is presented and conclusions are drawn. Author

**A87-19247\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FOLDING TILT ROTOR DEMONSTRATOR FEASIBILITY STUDY**

J. D. EISENBERG (NASA, Lewis Research Center, Cleveland, OH) and J. V. BOWLES (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 563-585. refs

This study considers the modification of existing aircraft to the folding tilt rotor (FTR) design configuration, and then addresses the vehicle design requirements necessary to demonstrate the FTR concept throughout the hover/transition high-speed envelope. Three potential candidates are considered: (1) the Bell/Boeing V-22 Osprey combined with either the existing TF-34 convertible engine or a conceptual convertible engine utilizing the torque-converter-coupled fan configuration; (2) a combination of the same powerplants with a modified Lockheed S-3A Viking; and (3) the NASA/Army/BELL XV-15 airframe mated with a conceptual generic turboprop engine with a fixed-pitch fan coupled to the engine by means of a torque converter. Required aircraft modifications are identified and recommended R&D efforts for engine/rotor/airframe integration are presented. Author

**A87-19249****THE 'FENESTRON' - A SHROUDED TAIL ROTOR CONCEPT FOR HELICOPTERS**

R. MOUILLE and F. DAMBRA (Aerospatiale, Division Helicopteres, Marignane, France) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 597-606. refs

The paper presents a general review of the experience acquired and of the improvements achieved by Aerospatiale during eighteen years of operational utilization of the 'fan-in-fin' tail rotor concept on light and medium weight helicopters. The paper then covers broadly the research and development effort conducted in order to improve the fan-in-fin concept. These improvements mainly concern aerodynamics performance, handling qualities, noise, behavior in special environments and application of advanced technology to reduce weight and production cost. Limitations of the fan-in-fin application as a function of helicopter size is discussed. The fan-in-fin next generation characteristics based upon the latest research and development results are then illustrated.

Author

**A87-19250****LHX - NEW OPPORTUNITY FOR HELICOPTER DESIGN**

S. G. COCKERHAM IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 607-622.

The design characteristics of the LHX combat helicopter, designed to operate at 4000-ft altitude and 35 C, are discussed. Elements of the design will include 100 percent Quick Change of Mission Equipment and select embedded systems, longer and wider Center of Gravity travel, hot mockup of helicopter systems to complement the LHX with its built-in 'Fault Detection and Location System' at the unit level, and maximum adaptability to meet changes in operation. I.S.



**A87-19255\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

## FLIGHT EVALUATION OF HEIGHT RESPONSE CHARACTERISTICS FOR THE HOVER BOB-UP TASK AND COMPARISON WITH PROPOSED CRITERIA

W. S. HINDSON (NASA; Stanford University, Joint Institute of Aeronautics and Acoustics, CA), G. E. TUCKER, J. V. LEBACQZ, and K. B. HILBERT (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 685-709. refs

The CH-47B variable-stability helicopter was used to evaluate a range of height-response configurations while performing a precision hover bob-up task. The purpose of the study was to assess the validity of results obtained in previous ground-based and in-flight simulations in the context of a precision bob-up task and to provide additional flight data for inclusion in revisions to specifications for helicopter handling qualities. Height response characteristics were implemented using explicit model-following techniques, and the resulting CH-47B dynamics were validated using time-domain and frequency-domain data-analysis methods. The tests complemented the previous investigations by providing detailed pilot comments and ratings, and performance and control-utilization data that relate exclusively to the hover bob-up task. The results are compared with those from previous investigations and with new criteria that have been proposed for handling qualities requirements for helicopters. Author

**A87-19258\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

## INTRODUCTION TO GRASP - GENERAL ROTORCRAFT AEROMECHANICAL STABILITY PROGRAM - A MODERN APPROACH TO ROTORCRAFT MODELING

D. H. HODGES, A. S. HOPKINS, D. L. KUNZ, and H. E. HINNANT (NASA, Ames Research Center; U.S. Army, Aviation Systems Command, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 739-756. refs

The General Rotorcraft Aeromechanical Stability Program (GRASP), which is a hybrid between finite element programs and spacecraft-oriented multibody programs, is described in terms of its design and capabilities. Numerical results from GRASP are presented and compared with the results from an existing, special-purpose coupled rotor/body aeromechanical stability program and with experimental data of Dowell and Traybar (1975 and 1977) for large deflections of an end-loaded cantilevered beam. The agreement is excellent in both cases. I.S.

## A87-19260

### FLIGHT DEMONSTRATION OF HIGHER HARMONIC CONTROL (HHC) ON S-76

W. MIAO, S. B. R. KOTTAPALLI, and H. M. FRYE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 777-791. refs

An open loop higher harmonic control (HHC) system has been successfully flight tested on the Sikorsky S-76 up to a forward speed of 150 knots. This is the first demonstration of HHC on a 10,000 lb helicopter at moderately high airspeeds compared to previous full scale testing. This paper briefly describes the preflight analytical study conducted to define HHC design requirements, the flight test procedure, and a post-flight correlation study performed to validate the analysis for future use. A sample of the flight test data is presented. The flight test results demonstrate that for the 10,000 lb S-76, HHC can substantially reduce vibration without incurring severe penalties in blade loads and rotor performance. Key design issues associated with implementing HHC are discussed; these issues include HHC amplitude requirements, weight considerations, hydraulic power requirement, and servo seal life at the high frequencies associated with HHC. Author

## A87-19261

### DESIGN OF UH-1 CMRB TO MINIMIZE HELICOPTER VIBRATION

J. G. YEN and H. TANNER (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 793-800. refs

A composite main rotor blade (CMRB) was designed and flight-tested on an Army UH-1 helicopter. The CMRB was designed to be interchangeable in sets with the existing metal blades and to be superior in performance. To achieve the interchangeability, the CMRB was to be compatible with the existing hub, autorotation characteristics, control system dynamics, and aircraft vibration levels. In this paper, a brief description of the metal blade is made and dynamic analyses of the CMRB are presented. The effects of blade built-in twist, and blade planform on cockpit vibrations and rotor system loads are discussed. An analytical explanation is provided as to why the prototype CMRB produced high cockpit vibrations and how a production configuration of the CMRB was achieved. Correlations of analytical predictions and flight test data are presented. A brief summary of the aerodynamic performance and dynamic compatibility of the CMRB with the metal blade is also provided. Author

**A87-19262\*** Textron Bell Helicopter, Fort Worth, Tex.

### TOTAL ROTOR ISOLATION SYSTEM (TRIS) FLIGHT TEST RESULTS

D. R. HALWES (Bell Helicopter Textron, Fort Worth, TX) and J. H. CLINE (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 801-809.

The total rotor isolation system (TRIS) is a six-degree-of-freedom helicopter rotor vibration isolation system that has been installed on a 206LM helicopter in order to demonstrate a better-than-90-percent isolation of the fuselage from main rotor forces and moments. The results thus far obtained indicate a 95-percent suppression of vibration levels from the rotor hub to the pilot's seat, with considerable weight savings over traditional antiresonant isolation concepts. O.C.

## A87-19263

### HIGHER HARMONIC CONTROL - FLIGHT TESTS OF AN EXPERIMENTAL SYSTEM ON SA 349 RESEARCH GAZELLE

M. POLYCHRONIADIS and M. ACHACHE (Aerospatiale, Division Helicopteres, Marignane, France) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 811-820. refs

A research program was designed for flight tests, on an SA 349 Gazelle, of an experimental system for active control of vibrations through higher harmonic control. Three control algorithms have been developed and tested in simulation; tests on rotor stand allowed checking for correct operation of the system and validating the algorithm logic. The flight test campaign conducted in 1985 led to: (1) validating the concept of reduction of vibrations with a self-adaptive system, throughout the SA 349 flight envelope; (2) demonstrating very large vibrations gains in closed-loop (80 percent reduction as an average in cabin, at 250 km/h; and (3) quantifying the effects of higher harmonic control on rotor and control systems. Author

A87-19264

**A COUPLED ROTOR/AIRFRAME VIBRATION MODEL WITH HIGHER HARMONIC CONTROL EFFECTS**

S. HANAGUD, M. MEYYPAPPA, S. SARKAR, and J. I. CRAIG (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 821-829. refs  
(Contract DAAG29-82-K-0094)

A technique to identify the transfer matrix in the higher harmonic control model using a known a priori matrix is presented. The identified matrix is such that it differs the least from a priori transfer matrix and satisfies the constraints imposed by the measured vibration levels. Application of the technique is demonstrated by using an analytical helicopter model consisting of an assumed mode rotor model and a finite element beam fuselage model. Results of the numerical simulations indicate that the technique could lead to significant reduction in vibrations. Author

A87-19265

**FLIGHT TESTS OF AN OPEN LOOP HIGHER HARMONIC CONTROL SYSTEM ON AN S-76A HELICOPTER**

D. M. WALSH (United Technologies Corp., Sikorsky Aircraft Div., West Palm Beach, FL) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 831-843. refs

Flight tests of an open loop higher harmonic vibration control system were conducted on an S-76A helicopter during the early part of 1985. This paper discusses the design, conduct and results of those tests. The flight tests included evaluations of Higher Harmonic Control (HHC) inputs in the longitudinal, lateral and collective axes at varying amplitudes and phases. These flight tests have demonstrated the feasibility of HHC on a medium size, high speed helicopter. Significant vibration reductions throughout the aircraft were demonstrated at forward speeds up to 150 knots. The capability of HHC to reduce vibrations was also demonstrated at varying rotor speeds and during maneuvers. Structural data obtained during testing showed a general increase in control system loads during HHC operation. However, no loads were above structural limits and it appears that a control system could be designed with sufficient strength to accept all HHC loads. No observable degradation of aircraft performance was noted during limited performance testing with the HHC system operational.

Author

A87-19267

**STATIC TEST AND FLIGHT TEST OF THE ARMY/BELL ACAP HELICOPTER**

D. REISDORFER (Bell Helicopter Textron, Fort Worth, TX) and L. T. MAZZA (U.S. Army, Aviation Applied Technology, Directorate, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 865-872.

The static test of the Army/Bell Advanced Composite Airframe Program (ACAP) Static Test Article has recently been completed and flight testing of the Flight Test Vehicle is now ongoing. This paper discusses the techniques that have been used in testing these two airframes and highlights the special test considerations that have been developed for composite structures during this program. The topics discussed include: (1) methods of accounting for environmental degradation effects on composite materials in static tests; (2) application of static test results as verification of structure for safety of flight; and (3) instrumentation accuracy requirements and difficulties in measuring true strains in nonhomogeneous materials. The paper concludes with philosophies and techniques recommended to be explored for improved test methods in future programs. Author

A87-19268

**EARLY EVALUATION OF THE V-22 OSPREY THROUGH PILOTED SIMULATION**

N. N. BATRA, D. F. KIMBALL (Bell Helicopter Textron, Fort Worth, TX), and T. A. SHEEHAN (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 873-883. refs

This paper describes the objectives, methods, and significant achievements of the piloted simulation effort during preliminary design of the V-22 Osprey. The Generic Tilt Rotor math model used for simulation is described, as are the specific simulation tasks that were developed to permit evaluation of the tilt rotor flight characteristics under operational conditions. Tests for the selection of cockpit controller configuration, the power lever retention method and orientation, the evaluation of flight characteristics, and the cockpit display development are discussed. The joint Bell, Boeing, and NASA simulation evaluations provided a comprehensive preview of the aircraft handling qualities in simulated mission oriented tasks. Author

A87-19269

**HELICOPTER DE-ICING SYSTEM DEVELOPMENT AND QUALIFICATION FLIGHT IN NATURAL ICING VERSUS SIMULATION AND ANALYSIS**

K. LUNN, P. J. DUNFORD, and G. E. HENSCHKE (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 889-906. refs

The criteria which must be met to qualify a helicopter for flights in icing conditions are discussed. It is shown that the existing methods of evaluation based on actual flight tests in natural or simulated icing conditions either require a very large data base or, in case of limited testing, result in unacceptable level of confidence. A pretest thermal modeling prediction-correlation technique is outlined which offers a practical, cost-effective method of supplementing and extending flight test data. I.S.

A87-19270

**ICE PROTECTION THERMAL MODELLING TECHNIQUES**

A. A. PETERSON, R. C. JOHNSON, and A. D. CIPOLLONI (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 907-915. refs

Rotorcraft present unique problems during the analysis, design and test of ice protection systems because of the need to provide protection for both rotating and non-rotating subsystems from the detrimental effects of ice accretion, ice shedding and ice ingestion over a wide range of flight icing conditions. Which much experimental effort has and is going into the investigation of non-thermal ice protection approaches such as pneumatic boots, fluid or electro-impulse, thermal systems currently present the only proven means to achieve satisfactory protection of ice sensitive subsystems such as rotors, engine inlets, windshields, sensors and probes. The need, therefore, is to determine the most efficient use of local power distribution and power-on times through the use of impingement analysis and thermal modelling techniques for both steady state and transient conditions that can account for the icing environmental conditions as well as the structural (i.e., material properties) considerations. Author

A87-19271\* Toledo Univ., Ohio.

**A NUMERICAL AND EXPERIMENTAL INVESTIGATION OF ELECTROTHERMAL AIRCRAFT DEICING**

K. LEFFEL, K. C. MASIULANIEC, K. J. DEWITT, and T. G. KEITH, JR. (Toledo, University, OH) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 917-930. NASA-supported research. refs

Experimental data were obtained for the deicing characteristics of a stationary UH-1H helicopter blade which had been fitted with

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an electrothermal deicer assembly. The tests were run in the NASA Lewis Icing Research Tunnel, and yielded transient temperature responses for the substrate, heater and abrasion shield at selected positions around the blade. The data at the abrasion shield-ice interface clearly documented when melting, shedding or refreezing occurred. Comparisons were made between the experimental data and a one-dimensional numerical model. The agreement was generally very good, with the simulations being shown to be capable of predicting the transient temperature responses along with phase change and ice shedding. At many blade positions, the model was capable of accurately simulating the thermal response of the electrothermal deicer assembly. Author

**A87-19272**

### **APPLICATION OF ROTOR ICING ANALYSES TO THE DESIGN OF A ROTORCRAFT DEICING SYSTEM**

R. J. FLEMMING (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 931-941. refs

Icing correlations are presently developed on the basis of test data for the accretion of artificial ice on an airfoil, in order to predict helicopter rotor and propeller performance in icing conditions and thereby establish design requirement for electrothermal and various other advanced deicing systems. The present analysis has also been used to predict the climb capabilities of aircraft subject to icing conditions, with a view to the effects of an optimized deicing system on payload-range characteristics. Attention is also given to the effect of grit on simulated rime ice accretions. O.C.

**A87-19273**

### **DEICING THE MCDONNELL DOUGLAS AH-64A**

T. C. KNIGHT and J. E. RITTER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 943-953. refs

The ability of the AH-64A Advanced Attack Helicopter to safely operate in a natural icing environment was evaluated using icing wind tunnel tests and tests under conditions of natural and artificial icing. The AH-64A is equipped with various defogging, antiicing, deicing, and ice-detecting devices, which include heated windshields and electrothermal heating systems. The results indicate that the AH-64A helicopter can be safely flown in moderate icing conditions and will achieve the qualifications of a 24-h all-weather tank killer. I.S.

**A87-19281\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **SUPERSONIC STOVL FIGHTER CONCEPTS FEATURING THE HYBRID TANDEM-FAN PROPULSION SYSTEM**

P. A. GELHAUSEN and S. B. WILSON, III (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1071-1078. refs

Current research on vertical- or short-takeoff-and-landing (V/STOL) aircraft is concentrating on developing a multirole-capable fighter. Several V/STOL concepts being studied show a capability performing for short-takeoff and vertical-landing (STOVL) missions. This paper is concerned with a propulsion concept which promises added flexibility in mission performance: the hybrid-tandem fan. This propulsion concept is combined with four aircraft planforms and the performance of each is evaluated on a representative mission. The four aircraft planforms used in the study are a conventional wing-tail, a forward-swept wing and canard, a delta-wing and canard, and an oblique wing and tail. The mission was chosen so that the four aircraft all had approximately the same gross takeoff weight. The four designs are compared at various phases of the mission. Author

**A87-19286**

### **DESIGN VERIFICATION AND FLIGHT TESTING OF A BEARINGLESS SOFT INPLANE TAIL ROTOR**

B. ENENKL and V. KLOEPPEL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1113-1126. refs

A composite experimental tail rotor has been developed with the objectives of improved aerodynamic efficiency, gains in simplicity, and reduction in weight and cost. The design uses a fiberglass bending-torsion-flexbeam to accommodate bending deflections and collective pitch control. Theoretical studies are presented dealing with dynamic characteristics, aeromechanic and aeroelastic stability problems, and load and stress aspects. Basic ground and flight testing on a BK 117 helicopter is presented. These tests were performed to verify ground and air resonance stability and to check the rotor loads as well as the aerodynamic and flight mechanic characteristics. Author

**A87-19287\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **THE ROLE OF MODELING AND FLIGHT TESTING IN ROTORCRAFT PARAMETER IDENTIFICATION**

R. T. N. CHEN (NASA, Ames Research Center, Moffett Field, CA) and M. B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, 38 p. refs

The importance of recognizing that each lower-order model used for rotorcraft parameter identification has a limited range of applicability is illustrated in some detail. Examples are given to illustrate the use of conditioning the test input signals and the potential of using multi-axis test inputs to enhance the parameter identifiability. The paper discusses the benefits and limitations of using frequency sweeps as flight-test input signals for identification of frequency response for rotorcraft and for the subsequent fitting of parametric transfer-function models. This paper demonstrates the major role played by analytical modeling and the understanding of the physics involved in the rotorcraft flight dynamics, particularly understanding the limit of lower-order models, in achieving successful rotorcraft parameter identification. Author

**A87-19288**

### **DESIGN OF THE MCDONNELL DOUGLAS HELICOPTER COMPANY - ADVANCED COMPOSITE ROTOR SYSTEM**

R. E. HEAD, J. V. ALEXANDER, and C. W. HUGHES, JR. (McDonnell Douglas Helicopter Co., Tempe, AZ) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, 6 p.

An advanced all-composite rotor system designed in the framework of HARP (Hughes Advanced Rotor Program) is described. The features of the HARP rotor include an advanced composite hingeless hub and four advanced composite blades which incorporate new high performance airfoils. The rotor has been in flight tests since the spring of 1985; it has covered the flight envelope of the MD 500E with no structural problems, while the pilots reported outstanding flying qualities. I.S.

**N87-13427\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **COMPUTER CODE TO INTERCHANGE CDS AND WAVE-DRAW GEOMETRY FORMATS**

V. S. JOHNSON and D. L. TURNOCK Dec. 1986 40 p  
(NASA-TM-88988; NAS 1.15:88988) Avail: NTIS HC A03/MF A01 CSCL 01C

A computer program has been developed on the PRIME minicomputer to provide an interface for the passage of aircraft configuration geometry data between the Rockwell Configuration Development System (CDS) and a wireframe geometry format used by aerodynamic design and analysis codes. The interface program

allows aircraft geometry which has been developed in CDS to be directly converted to the wireframe geometry format for analysis. Geometry which has been modified in the analysis codes can be transformed back to a CDS geometry file and examined for physical viability. Previously created wireframe geometry files may also be converted into CDS geometry files. The program provides a useful link between a geometry creation and manipulation code and analysis codes by providing rapid and accurate geometry conversion. Author

**N87-13428\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**GROUND VIBRATION TEST AND FLUTTER ANALYSIS OF AIR SAMPLING PROBE**

J. F. ELLISON Nov. 1986 34 p  
(NASA-TM-86742; H-1302; NAS 1.15:86742) Avail: NTIS HC A03/MF A01 CSCL 01C

The Dryden Flight Research Facility of NASA Ames Research Center conducted a ground vibration test and a flutter analysis of an air sampling probe that was to be mounted on a Convair 990 airplane. The probe was a steel, wing-shaped structure used to gather atmospheric data. The ground vibration test was conducted to update the finite-element model used in the flutter analysis. The analysis predicted flutter speeds well outside the operating flight envelope of the Convair 990 airplane. Author

**N87-13429#** Army Aviation Engineering Flight Activity, Edwards AFB, Calif.

**HELICOPTER ICING SPRAY SYSTEM (HISS) EVALUATION AND IMPROVEMENT Final Report, 1984 - 1985**

D. BELTE and R. WORATSCHEK Apr. 1986 156 p  
(AD-A170732; USAAEFA-82-05-3) Avail: NTIS HC A08/MF A01 CSCL 01C

The US Army Aviation Engineering Flight Activity operates a modified CH-47C helicopter as an airborne spray tanker for helicopter qualification tests in artificial icing conditions. The operational performance and spray cloud characteristics of the Helicopter Icing Spray System were evaluated in the course of several test programs during the 1984 and 1985 icing seasons in Duluth, Minnesota. Configuration changes made during the first two phases of this program reduced previous spray system problems of water leakage, freezing, and non-uniform flow patterns from the boom assembly. In-flight spray cloud data taken with a JU-21A aircraft using particle measuring spectrometers found peak mass concentrations in the desired 15 to 25 micron drop diameter range as well as the presence of larger drops (>50 microns) not normally found in natural stratiform clouds. Many aspects of ice formation produced on various test aircraft compared favorably to natural accretions. Ability of the artificial cloud to produce non-streamlined double-horn ice shapes on main rotor blades at -5 C was substantiated for the first time. GRA

**N87-13430#** Air Force Test Pilot School, Edwards AFB, Calif.  
**USAF TEST PILOT SCHOOL. PERFORMANCE PHASE TEXTBOOK, VOLUME 1**

Apr. 1986 1049 p  
(AD-A170957; USAF-TPS-CUR-86-01) Avail: NTIS HC A03/MF A03 CSCL 01B

Aircraft performance, in its most general sense configuration, can be defined as the flight achievements an aircraft must execute for successful mission accomplishment. Obviously, expected performance parameters must be an integral part of the design process of an aircraft. Given certain performance expectations by the customer, the designer must make decisions regarding wing loading, power plant selection, airfoil selection, planform configuration, and myriad other considerations. All of these help to tailor the design to give the aircraft certain desired performance characteristics. It is also certain that actual performance characteristics will not always be the same as those predicted by the designer. Herein lies the need for performance flight testing. Performance flight testing is defined as the process of determining aircraft performance characteristics, or in a more modern sense,

evaluation of the energy gaining and losing capability of the aircraft. GRA

**N87-13431#** Air Force Test Pilot School, Edwards AFB, Calif.  
**USAF TEST PILOT SCHOOL. FLYING QUALITIES TEXTBOOK, VOLUME 2, PART 1**

Apr. 1986 703 p  
(AD-A170959; USAF-TPS-CUR-86-02) Avail: NTIS HC A99/MF A02 CSCL 01B

Flying Qualities is that discipline in the aeronautical sciences that is concerned with basic aircraft stability and pilot-in-the-loop controllability. With advent of sophisticated flight control systems, vectored thrust, forward-swept wings, and negative static margins, the concept of flying qualities takes on added dimensions. In aeronautical literature there are three terms bandied about which are generally considered synonymous. These terms are flying qualities, stability and control, and handling qualities. Strictly speaking, they are synonymous. An early publication by Phillips in 1949 defines flying qualities of an aircraft as those stability and control characteristics that have an important bearing on the safety of flight and on the pilots' impressions of the ease of flying an aircraft in steady flight and in maneuvers. The specification's stated purpose of application is to assure flying qualities that provide adequate mission performance and flight safety regardless of design implementation or flight control system mechanization. Successful execution of the military mission then is the key to flying quality adequacy. A definition of flying qualities which can be agreed upon by both the USAF and the US Navy is: Flying qualities are those stability and control characteristics which influence the ease of safely flying an aircraft during steady and maneuvering flight in the execution of the total mission. GRA

**N87-13432#** Air Force Test Pilot School, Edwards AFB, Calif.  
**USAF TEST PILOT SCHOOL. FLYING QUALITIES TEXTBOOK, VOLUME 2, PART 2**

Apr. 1986 931 p  
(AD-A170960; USAF-TPS-CUR-86-03) Avail: NTIS HC A99/MF A02 CSCL 01B

Divergence experienced during rolling maneuvers has frequently been referred to as inertial coupling. This leads to a misconception of the problems involved. The divergence experienced during rolling maneuvers is complex because it involves not only inertial properties, but aerodynamic ones as well. The material in this chapter is intended to offer a physical explanation of the more important causes of roll coupling. Coupling results when a disturbance about one aircraft axis causes a disturbance about another axis. An example of uncoupled motion is the disturbance created by an elevator deflection. The resulting motion is restricted to pitching motion, and no disturbance occurs in yaw or roll. An example of coupled motion is the disturbance created by a rudder deflection. The ensuing motion will be some combination of both yawing and rolling that results in coupling problems large enough to threaten the structural integrity of the aircraft. GRA

**N87-13433#** Fairchild Republic Co., Farmingdale, N.Y.  
**ASSESSMENT OF DAMAGE TOLERANCE REQUIREMENTS AND ANALYSIS. VOLUME 3: ANALYTICAL PREDICTIONS AND CORRELATIONS Final Technical Report, Sep. 1982 - Mar. 1986**

M. LEVY 31 Mar. 1986 133 p  
(Contract F33615-82-C-3215)  
(AD-A170989; AFWAL-TR-86-3003-VOL-3) Avail: NTIS HC A07/MF A01 CSCL 01C

Structural test program of typical aircraft structural configuration was conducted to assess the current Air Force damage tolerance design requirements defined in MIL-A-83444. The specimens, made of 2024-T3XX and 7075-T6XX, were subjected to randomized flight-by-flight spectra, representative of fighter/trainer and bomber/cargo type loading spectra, respectively, and to constant amplitude loading spectrum. A total of seventy-two (72) specimens were tested. The test results were correlated with analytical predictions using crack growth and crack initiation methods. As a result of this study, recommendation is provided to the validity of

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MIL-A-83444, to develop guidelines for selection of critical crack locations, and to assess the state-of-the-art analytical capabilities in prediction crack growth and crack initiation time.

Author (GRA)

**N87-13434#** Fairchild Republic Div., Farmingdale, N. Y.  
**ASSESSMENT OF DAMAGE TOLERANCE REQUIREMENTS AND ANALYSIS. VOLUME 4: RAW TEST DATA Final Technical Report, Sep. 1982 - Nov. 1985**

M. LEVY 31 Mar. 1986 369 p

(Contract F33615-82-C-3215)

(AD-A170990; AFWAL-TR-86-3003-VOL-4) Avail: NTIS HC A16/MF A01 CSCL 01C

Structural test program of typical aircraft structural configuration was conducted to assess the current Air Force damage tolerance design requirements defined in MIL-A-83444. The specimens, made of 2024-T3XX and 7075-T6XX, were subjected to randomized flight-by-flight spectra, representative of fighter/trainer and bomber/cargo type loading spectra, respectively, and to constant amplitude loading spectrum. A total of seventy-two (72) specimens were tested. The test results were correlated with analytical predictions using crack growth and crack initiation methods. As a result of this study, recommendation is provided to the validity of MIL-A-83444, to develop guidelines for selection of critical crack locations, and to assess the state-of-the-art analytical capabilities in prediction crack growth and crack initiation time. GRA

**N87-13435#** Dikewood Corp., Albuquerque, N. Mex.  
**EXTERIOR ELECTROMAGNETIC RESPONSE OF NASA F-106 AIRCRAFT Final Report, Jan. 1983 - Apr. 1985**

V. V. LIEPA and S. T. PENNOCK Jun. 1986 77 p

(Contract F29601-82-C-0027; AF PROJ. 3763)

(AD-A171875; DC-FR-1026.330-3; AFWAL-TR-85-95) Avail: NTIS HC A05/MF A01 CSCL 01C

Frequency domain surface current and charge data are presented for the NASA F-106B aircraft when illuminated with a plane electromagnetic wave. Measurements were made on a 1:48 scale F-106A model that had been modified to represent the NASA F-106B. The measurement locations and the field quantities measured correspond to those on the NASA aircraft. Nine different excitations were used including those corresponding to the situations in HPD, VPD-11, and VPD-II fly-by tests performed at Kirtland Air Force Base. The amplitude and phase measurements on the models were performed over 100 to 4770 MHz and for the full scale aircraft this corresponds to 2.1 to 100 MHz coverage. GRA

**N87-13436#** Centre d'Essais en Vol, Istres (France).  
**CERTIFICATION OF THE PIK30 POWERED GLIDER [CERTIFICATION DU PLANEUR PROPULSE PIK 30]**

13 May 1986 25 p In FRENCH

(REPT-5/CEV/IS/SE/AV/86; REPT-13670; ETN-86-98423)

Avail: NTIS HC A02/MF A01

The results of two test campaigns are presented including a configuration with the original horizontal tail surface and with a modified one. The PIK 30 is a glider with a retractable propulsion system. The poor test results regarding longitudinal stability caused a tail design modification which resulted in a satisfactory performance. ESA

**N87-13437#** National Aerospace Lab., Amsterdam (Netherlands). Flight Div.

**TRENDS IN AIRLINER FLIGHT DECK DESIGN**

F. J. ABBINK and E. W. PIJERS 28 Jan. 1985 104 p Presented at the Symposium on Developments in the Cockpit, Haarlem, Netherlands, 21 Mar. 1986

(NLR-MP-85007-U; B8668291; ETN-86-98656) Avail: NTIS HC A06/MF A01

The development of the airliner structure, engines and systems, and the impact on the cockpit design are reviewed. The influence of the developments of microelectronics, digital computer technology, and display technology on the avionics design and cockpit layout of airliners such as the Airbus A-310 is discussed.

An extrapolation with respect to the design of the flight deck of future airliners is given, based on developments in microwave landing systems, satellite navigation systems, all electric aircraft technology, control configured vehicle technology, data link technology, and advanced air traffic control. ESA

**N87-14248#** National Aerospace Lab., Tokyo (Japan).

**NUMERICAL SIMULATION OF AN AIRCRAFT ICING**

D. TAKAHASHI and K. KUWAHARA In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 1-6 Nov. 1985 In JAPANESE; ENGLISH summary

Avail: NTIS HC A12/MF A01

A finite difference method was developed to simulate aircraft icing. An air flow was calculated by solving compressible Navier-Stokes equations directly. The accretion of ice to the NACA0012 airfoil at various angles of attack was calculated from trajectories of supercooled liquid drops through that flow. Author

**N87-14275#** National Aerospace Lab., Tokyo (Japan).

**TRANSONIC WING AND AIRFOIL DESIGN USING INVERSE CODE WINDES**

S. TAKANASHI In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 251-256 Nov. 1985 In JAPANESE; ENGLISH summary

Avail: NTIS HC A12/MF A01

An iterative design procedure is presented for two- and three-dimensional transonic wings with prescribed (target) pressure distributions. The inverse code WINDES is used in combination with existing flow analysis codes in the iterative design method. The iteration proceeds in the following steps: First, the flow field is solved for an initially assumed wing by an analysis code. Next, WINDES is operated, which provides the approximate amount of wing geometry correction needed to compensate for the difference between the computed and the target pressure distributions. Consequently a new wing is obtained which can be used again as the input data for the analysis code. The same process is repeated until convergence is achieved. The advantage of the present approach is that the analysis code is retained in its original form and therefore can be treated as a black box. The adoption of several analysis codes for potential, Euler, and Navier-Stokes equations was successfully applied to transonic design problem. Author

**N87-14276#** National Aerospace Lab., Tokyo (Japan).

**APPLICATION OF COMPUTATIONAL AERODYNAMICS TO WING DESIGN UNDER FUSELAGE INTERFERENCE**

S. HIRANO and N. SHINOKAWA In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 257-265 Nov. 1985 In JAPANESE; ENGLISH summary

Avail: NTIS HC A12/MF A01

Recent progress in computational aerodynamics has enabled the engineers of aircraft manufacturers to utilize transonic aerodynamic analysis programs in designing wings. Application of computer codes to the wing-body combination study of transonic transport aircraft is introduced. The computational results are compared with wind-tunnel test data. The problems of the present analysis program and the capabilities required in future programs are also presented. Author

**N87-14277#** National Aerospace Lab., Tokyo (Japan).

**THE ROLE OF COMPUTATIONAL FLUID DYNAMICS IN AERONAUTICAL ENGINEERING: THIRD REPORT**

T. NOHISA, T. UCHIDA, T. JYONOUCHI, and K. SAWADA In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 267-276 Nov. 1985 In JAPANESE; ENGLISH summary

Avail: NTIS HC A12/MF A01

Recently, a flow analysis based on the Euler/Navier-Stokes equations has become more important and necessary in aerodynamic design. Therefore codes, based on the Beam-Warming-Steger (2-D, axisymmetric) method, were developed in KHI to solve the Euler/Navier-Stokes (thin-layer) equations. So far the calculation time required to get the final

result is too long and the codes lack robustness. Some attempts were made to improve them. Presented are: comparison of some calculation results of the KHI Euler code with Jameson's FLO 54; application of the multigrid method and the local-variable-time-step method to KHI Euler code (these applications shorten the time steps needed for convergence); and some of the results obtained with KHI's Navier-Stokes code. Author

**N87-14313** Civil Aviation Authority, London (England).  
**REPORT OF THE WORKING GROUP ON HELICOPTER HEALTH MONITORING**

Aug. 1985 93 p Presented at Recommendations of the Helicopter Airworthiness Review Panel (HARP), London, England (CAA-PAPER-85012; HARP-CAP-491; ISBN-0-86039-250-3; ETN-87-98601) Avail: Issuing Activity

Proposed airworthiness requirements for future helicopters were studied to define the health monitoring improvements needed to realize the intended safety objectives. Results show that major benefits can be expected from exploiting health monitoring, not only on future helicopters, but also by retrospective application to those in service. Health monitoring is particularly relevant to the transmission, rotor systems, flight control system, and engines. Current technology can provide airworthiness and reliability benefits. Research or application developments required are listed. ESA

**N87-14314\*** National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**REMOTE PIVOT DECOUPLER PYLON: WING/STORE FLUTTER SUPPRESSOR Patent**

J. M. HASSLER, JR., inventor (to NASA) (General Dynamics/Fort Worth, Tex.) 14 Oct. 1986 7 p Filed 10 Jan. 1985 Supersedes N85-19981 (22 - 19, p 2996) Sponsored by NASA (NASA-CASE-LAR-13173-1; US-PATENT-4,616,793; US-PATENT-APPL-SN-690274; US-PATENT-CLASS-244-137-A; US-PATENT-CLASS-244-17.27; US-PATENT-CLASS-244-118.1; US-PATENT-CLASS-89-1.54; US-PATENT-CLASS-248-638) Avail: US Patent and Trademark Office CSCL 01C

A device for suspending a store from an aerodynamic support surface, such as an aircraft wing, and more specifically, for improving upon singlet pivot decoupler pylons by reducing both frequency of active store, alignment, and alignment system space and power requirements. Two links suspend a lower pylon/rack section and releasable attached store from an upper pylon section mounted under the wing. The links allow the lower pylon section to rotate in pitch about a remote pivot point. A leaf spring connected between the lower section and electrical alignment system servomechanism provides pitch alignment of the lower section/store combination. The servomechanism utilizes an electric servomotor to drive the gear train and reversibly move the leaf spring, thereby maintaining the pitch attitude of the store within acceptable limits. The damper strokes when the lower section rotates to damp large oscillations of store.

Official Gazette of the U.S. Patent and Trademark Office

**N87-14315#** General Accounting Office, Washington, D. C. National Security and International Affairs Div.

**DOD (DEPARTMENT OF DEFENSE) ACQUISITION: CASE STUDY OF THE NAVY V-22 OSPREY JOINT VERTICAL LIFT AIRCRAFT PROGRAM**

Jul. 1986 17 p (PB86-231388; GAO/NSAID-86-45S-7) Avail: NTIS HC A02/MF A01 CSCL 01C

This study of the Joint Services Advanced Vertical Lift Aircraft Program describes the role of the program manager and contracting officer in developing the acquisition strategy. GRA

**N87-14316** Royal Aircraft Establishment, Farnborough (England).

**A METHOD FOR THE MANUFACTURE OF MODEL HELICOPTER ROTOR BLADES FROM GLASS FIBER REINFORCED PLASTIC**

A. R. LEE Apr. 1985 27 p (RAE-TR-85040; RAE-MAT/STRUCT-122; BR97931; ETN-86-98372) Avail: NTIS HC A03/MF A01

A method for constructing model helicopter rotor blades for a 24 ft wind tunnel rig was developed. Several methods for the manufacture of the blades, which have a glass fiber reinforced plastic (GFRP) spar and a balsa trailing edge section were evaluated. The advantages and disadvantages of each method are discussed, and the technique accepted for the blades used in wind tunnel tests is described. The technique uses laminated prepreg GFRP sheet for the spar and aluminum alloy female molds with an inflatable silicone rubber tube within the spar to consolidate the laminate. ESA

**N87-14317\*#** National Aeronautics and Space Administration, Washington, D.C.

**AN OVERVIEW OF THE BRITISH AEROSPACE HOTOL TRANSATMOSPHERIC VEHICLE**

J. MESNARD Oct. 1986 7 p Transl. into ENGLISH from AviMag (France), no. 915, 1 Apr. 1986 p 34-35 Translated by The Corporate Word, Inc., Pittsburgh, Pa.

(Contract NASW-4006) (NASA-TM-88008; NAS 1.15:88008) Avail: NTIS HC A02/MF A01 CSCL 51C

British Aerospace's space-going aircraft and economical launcher Hotol, so named for its horizontal take-off and landing ability, is described. The craft uses Rolls Royce's new Swallow engine, the principle behind which is still secret, which burns atmospheric oxygen until it leaves the atmosphere and then switches to liquid oxygen. This lightens the craft's fuel load tremendously, so that it can carry significant payloads and still take off and land like a normal airplane. A typical future mission for the craft is described. Author

**N87-14318\*#** National Aeronautics and Space Administration, Washington, D.C.

**DEEP STALL CHARACTERISTICS OF MU-300**

T. HANAI Sep. 1986 14 p Transl. into ENGLISH from Japan Society for Aeronautical and Space Sciences Journal (Japan), v. 33, no. 377, Jun. 1985 p 322-325 Original language document was announced in IAA as A86-25203 Transl. by Kanner (Leo) Associates, Redwood City, Calif.

(Contract NASW-4005) (NASA-TM-88502; NAS 1.15:88502; ISSN-0021-4663) Avail: NTIS HC A02/MF A01 CSCL 51C

The deep stall characteristics of the MU-300 Diamond aircraft are described. The MU-300 obtained type certification from the FAA in 1981, and from Canada, West Germany, and England in 1983. The aircraft has achieved a high angle of attack. The aerodynamic design, structural dimensions, and flight tests of the MU-300 are described. Author

**N87-14319#** Fairchild Industries, Inc., Farmingdale, N.Y.  
**ASSESSMENT OF DAMAGE TOLERANCE REQUIREMENTS AND ANALYSIS, TASK 1 REPORT. VOLUME 2: ANALYTICAL METHODS Final Technical Report, Sep. 1982 - Jun. 1984**

A. KUO, D. YASGUR, and M. LEVY 31 Mar. 1986 133 p (Contract F33615-82-C-3215) (AD-A170327; AFWAL-TR-86-3003-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 13M

The stress intensity factor and stress severity factor for typical airframe structures have been formulated using the compounded solution method. Two-dimensional and three-dimensional finite element analysis were performed to validate or obtain some of the factors. Two damage tolerance analysis methods have been developed based upon the stress intensity factor and stress severity factor. The first method is based on crack growth only. The second method is based on the combined crack growth and initiation.



## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

The strain energy density is proposed as the governing parameter of fatigue crack initiation. Author (GRA)

**N87-14321#** Texas A&M Univ., College Station. Dept. of Mechanical Engineering.

### **NONLINEAR DYNAMIC RESPONSE OF COMPOSITE ROTOR BLADES Final Report**

J. J. ENGBLOM and O. O. OCHOA Jan. 1986 97 p (Contract F49620-82-K-0032) (AD-A173069; ME-4786-85-10; AFOSR-86-0934TR) Avail: NTIS HC A05/MF A01 CSCL 11D

This report summarizes research related to nonlinear dynamic response of composite rotor blades. Fundamental to the analysis is the development of a continuum formulation that can accurately account for the effects of interlaminar shear and interlaminar normal stress variation thru-the-thickness of a laminate. Technical highlights of the research efforts to date are presented for each of the proposed tasks--namely, nonlinear displacement formulation for composite media, incorporate damage mechanisms into dynamic response formulation, and correlation of formulated response model with experimental data. GRA

### **N87-14322# Sandia National Labs., Albuquerque, N. Mex. ANALYSIS OF SHOCK AND VIBRATION ENVIRONMENTS FOR CARGO ON C9B TRANSPORT AIRCRAFT**

T. J. BACA, J. W. DOGGETT, and C. A. DAVIDSON 1986 15 p Presented at the 57th Shock and Vibration Symposium, New Orleans, La., 14 Oct. 1986 (Contract DE-AC04-76DP-00789) (DE86-016101; SAND-86-1238C; CONF-8610140-2) Avail: NTIS HC A02/MF A01

The definition of shock and vibration environments on the floor of cargo aircraft is of prime interest to designers of hardware which must be transported on these planes and helicopters. The DOE/DOD Environmental Data Bank at Sandia National Laboratories maintains an extensive collection of environmental definitions for aircraft. This paper describes the process involved in acquiring and analyzing shock and vibration data on the cargo floor of a C9B turbojet aircraft for incorporation into the DOE/DOD Environmental Data Bank. The dual objectives of this paper are to show the procedure by which the environmental definition is created and to compare the results with existing definitions of shock and vibration environments on fixed wing aircraft. Special emphasis is placed on instrumentation considerations which help ensure data integrity. DOE

### **N87-14323# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.**

#### **MEASUREMENTS OF LANDING GEAR LOADS OF A COMMUTER AIRLINER**

A. I. GUSTAVSSON Jun. 1986 10 p Presented at the 15th ICAS Congress, London, England, 7-12 Sep. 1986 Previously announced in IAA as A86-49119 Sponsored by the Swedish Board for Technical Development (FFA-TN-1986-37; ETN-86-98557) Avail: NTIS HC A02/MF A01

Strain gage measurements of forces acting on the nose gear and main gears of a SAAB SF-340 airliner are described. Forces in the longitudinal, transversal, and vertical directions are presented for takeoff, landing, taxiing, and towing. The investigation reveals unexpectedly high transversal loads at the main gears at touchdown. The nose gear is most severely strained when steering during taxiing run and when the aircraft is towed, connected to a tractor with a tow-bar. The results of the measurements formed the basis for an investigation with on-line data acquisition of landing gear loads on a commuter airliner in service. Such measurements reveal differences in load environment due to different pilots, runways, and weather conditions including seasonal variations. The data acquisition system and the data analysis methods are outlined. ESA

**N87-14324#** European Space Agency, Paris (France).

### **RESULTS OF ICING FLIGHTS IN WINTER 1983/1984: ICE ACCRETION THICKNESS IN CORRELATION WITH CLOUD PHYSICAL PARAMETERS, OBJECT AND CLOUD PARAMETERS**

H. E. HOFFMANN, R. ROTH, and J. DEMMEL Apr. 1986 41 p Original language document was announced as N86-15838 (ESA-TT-969; DFVLR-FB-85-39; ETN-87-98820) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne, West Germany DM 16

Twenty-five icing flights on a DO28 research aircraft were carried out to determine the correlation between ice accretion thickness on standard cylinders and cloud physical parameters (liquid water content, temperature, particle phase and size), object parameters (cylinder diameter) and cloud parameters (cloud altitude, location coordinates, time, stratus or cumulus). The relationship between ice accretion thickness and water content is demonstrated with the ice accretion model of the Canadian National Research Council. Effects of the cloud particle size on ice accretion thickness could not be shown. The ice accretion thickness change due to liquid water content depends on cylinder diameter. Liquid water content, ice accretion thickness, and icing degree increase with altitude. Stratus or cumulus have no effects on the ice accretion thickness. ESA

**N87-14325#** European Space Agency, Paris (France).

### **CALCULATION OF ICE ACCRETION ON CYLINDRICAL RODS ACCORDING TO BAIN'S MODEL AND COMPARISON WITH EXPERIMENTAL RESULTS**

W. FUCHS, K. P. SCHICKEL, J. KALUZA, and K. UWIRA Jun. 1986 83 p Original language document was announced as N86-18933 (ESA-TT-970; DFVLR-FB-85-46; ETN-87-98821) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne, West Germany DM 25.50

Bain's model for the calculation of ice accretion rates was compared with meteorological flight data. The Bain model for the determination of the ice accretion rate on cylindrical rods was extended to the calculation of the accretion shape and velocity in pure water clouds. The ice accretion was measured on an aircraft during flights in stratus clouds. By taking into account the energy balance estimate of Ludlam for the calculation of an upper bound on the spontaneously freezing supercooled liquid water content (LWC), good agreement between the calculated and measured ice accretion is obtained. The effect of higher LWC's on the ice accretion is not proportional, as theory shows. ESA

**N87-14326#** European Space Agency, Paris (France).

### **THE ICING RESEARCH AIRCRAFT DO28, D-IFMP OF DFVLR AND ITS MEASURING EQUIPMENT**

H. E. HOFFMANN and J. DEMMEL Apr. 1986 69 p Original language document was announced as N86-22064 (ESA-TT-972; DFVLR-MITT-85-12; ETN-87-98822) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne, West Germany DM 25.50

A Dornier Do28 D-IFMP, equipped as an icing research aircraft, is described. The accretion is measured on three metal cylinders and at the tip of one wing. The icing-relevant, cloud-physical parameters measured include air temperature, liquid water content, particle size (0.5 to 600 micron), particle concentration, particle phase (qualitative), visibility in and outside clouds, relative humidity, and absolute humidity. The measured data are recorded on two analog and one digital recorder. ESA

**N87-14327#** European Space Agency, Paris (France).

**THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF FLOW VECTOR MEASUREMENTS WITH ANGLE-OF-ATTACK AND SIDESLIP SENSORS ON DFVLR METEOROLOGICAL RESEARCH AIRCRAFT**

P. MUEHLBAUER Apr. 1986 158 p Original language document was announced as N86-21541

(ESA-TT-976; DFVLR-FB-85-50; ETN-87-98824) Avail: NTIS HC A08/MF A01; original German version available from DFVLR, Cologne, West Germany DM 42.50

Calibration of the equipment of three powered sail planes and a jet plane with angle-of-attack and sideslip sensors for measuring the local flow vector, is described. The impact of angle-of-attack and sideslip and of other interfering parameters on the measured value was studied. A mathematical simulation of compressible flow at the tip of the probe is followed by experimental wind tunnel investigations, analysis, and application on inflight measurement. Criteria for flight-test use of the sensors are outlined. ESA

**N87-14328#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Unternehmensbereich Transport- und Verkehrsflugzeuge

**DEVELOPMENT OF A TECHNOLOGY FOR INCREASING PAYLOAD OF EXISTING AIRCRAFT (NEW 2) Final Report, Aug. 1985**

J. SZODRUCH Bonn, West Germany Bundesministerium fuer Forschung und Technologie Jul. 1986 85 p Sponsored by Bundesministerium fuer Forschung und Technologie (BMFT-FB-W-86-007; ISSN-0170-1339; ETN-87-98879) Avail: NTIS HC A05/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 18

Simulation of viscous effects on airfoils was investigated. Modifications at the leading and trailing-edge of the wing are described. Corresponding design for the modified high lift system was carried out. The improvement in payload/range and DOC was evaluated. The development of existing aircraft was enhanced and the technology of variable camber for transport aircraft was supported. ESA

## 06

### AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

**A87-16681\*** Tennessee Univ., Tullahoma.

**SENSOR-BASED FAULT DIAGNOSIS IN A FLIGHT EXPERT SYSTEM**

M. ALI and D. A. SCHARNHORST (Tennessee, University, Tullahoma) IN: The engineering of knowledge-based systems; Proceedings of the Second Conference on Artificial Intelligence Applications, Miami Beach, FL, December 11-13, 1985. Washington, DC, IEEE Computer Society Press, 1985, p. 49-54. FAA-supported research. refs (Contract NAG1-513)

A prototype of a knowledge-based flight expert system (FLES) has been developed to assist airplane pilots in monitoring, analyzing, and diagnosing faults and to provide support in reducing the pilot's own mistakes. A sensor simulation model has been developed to provide FLES with the airplane status information during the diagnostic process. The simulator is based partly on the Advanced Concept System (ACS), a future-generation airplane, and partly on the Boeing 737, an existing airplane. The architecture of FLES contains several subsystems. One of the major subsystems performs fault diagnosis in the electrical system of the ACS. This paper describes the mechanism and functionality of the automatic diagnosis performed in this expert system. Author

**A87-16705\*** E-Systems, Inc., Dallas, Tex.

**PROGRESS IN KNOWLEDGE-BASED FLIGHT MONITORING**

D. C. CHEN (E-Systems, Inc., Garland Div., Dallas, TX) IN: The engineering of knowledge-based systems; Proceedings of the Second Conference on Artificial Intelligence Applications, Miami Beach, FL, December 11-13, 1985. Washington, DC, IEEE Computer Society Press, 1985, p. 441-446. refs (Contract NAG1-288; F49620-82-K-0009)

Features and applications of the script-based flight monitor SECURE are described. Implemented on an on-board computer, SECURE treats a flight as a regular sequence of contexts (situations) defined in a knowledge base with a hierarchical structure for successively more finely delineated flight phases, i.e., takeoff, cruise and landing. SECURE provides normalcy references for flight monitoring and allows context identification, which allows the presentation of checklists. An implementation of SECURE, written in MACLISP, on a DC-10 flight simulator is described.

M.S.K.

**A87-16727**

**DESIGN FOR TESTABILITY FOR FUTURE DIGITAL AVIONICS SYSTEMS**

V. R. SUBRAMANYAM and L. R. STINE (TRW, Inc., San Diego, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 21-25. refs

An integrated approach, referred to as the Maintenance and Diagnostics System (MADS), for testing the applicability of VHSIC, VLSI, and semicustom circuits in digital avionics systems is described. The MADS defines a module maintenance node (MMN) chip set for each line replaceable unit. The use of the MADS to test sequential circuits, to eliminate test vector/response storage, and to enhance fast coverage and reduce error escape is discussed; the integrated test system also provides a reduction in test time and false alarm rates. I.F.

**A87-16729**

**A DIGITAL MAP SET FOR THE NIGHT ATTACK AIRCRAFT**

J. F. DAWSON (Sperry Corp., Aerospace and Marine Group, Albuquerque, NM) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 60-67. refs

The development of a moving map system for night attack aircraft is studied. Compression and decompression, scale and geometry, and projections and accuracy problems related to the use of digitized paper charts as a cartographic data base are examined. The characteristics of the digital terrain elevation data and the digital feature analysis data of the digital land mass system data base are discussed. The requirements for the digital map system which include dynamic format manipulation such as elevation color banding, sun angle shading selection, and cultural feature declutter are analyzed. I.F.

**A87-16730**

**AN EFFICIENT DATA HIERARCHY FOR INTEGRATING BACKGROUND IMAGE INFORMATION IN AN AIRCRAFT MAP SYSTEM**

S. WALKER, F. S. HILL, and J. J. KOONCE (Peregrine Computer Systems, Inc., Moultonboro, NH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 79-86. refs

Pilots many times need more complex information than simple line maps, and may benefit from a display showing a satellite photo (e.g., Landsat) of the local area or showing the configuration of a destination airfield. This paper presents efficient algorithms using the progressive transmission method of Knowlton (1980) to integrate a complex background image (such as Landsat or GOES image) into a hierarchical database for an aircraft map system.

Author



**A87-16737**

## **FAULT TOLERANCE - AN AFFORDABLE NECESSITY**

W. T. OREILLY and P. J. FERRARA (Westinghouse Defense and Electronics Center, Baltimore, MD) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 131-135.

Airborne weapon systems for the 21st century require operational capabilities that are not available in most present day systems. These systems must be able to fly and fight without the traditional logistic tail. These systems must provide sustained operation for hundreds of sorties with little or no maintenance, survive combat damage and in some cases be failsafe or fail operational. To achieve these capabilities requires that the systems embody a high degree of fault tolerance. This paper describes the redundant architecture which will provide the desired fault tolerance at the least cost. The paper also describes two new operational concepts: the War/Peace option and Deferred Maintenance. These concepts are made possible with an optimal redundant approach which will provide high sustainability at an affordable price. Author

**A87-16741#**

## **DYNAMIC HOLOGRAPHY FOR REAL-TIME 3-D COCKPIT DISPLAY**

D. G. HOPPER (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 166-172. refs

The concept of dynamic holography (DH) in pilot-to-aircraft systems interface devices is examined. Holograms provide a three-dimensional capability which would enhance the ability of the pilot to perceive the spatial relationship of other aircraft in his area when presented via display. Holographic movies have already been produced with play-back fields-of-view more than sufficient for cockpit display purposes. Such movies might provide storage of reference imagery. Dynamic holography, a technology by which holograms are read out as fast as they are written, may support the real-time portions of the display. Critical device developments required include degenerate four wave mixers (operational optical image amplifiers) and advanced real-time spatial light modulators. Author

**A87-16742#**

## **AIRCRAFT COLOR CRT EXPERIENCE**

J. C. BYRD (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 173-176.

This paper presents current projects which are installing and testing color cathode ray tube (CRT) displays on aircraft. Color CRTs are replacing monochrome CRTs as well as electromechanical instruments and indicators in several applications, and will be used in several more applications in the near future. The USAF's experience with installations on the F-15 and a remote map reader test project is presented. Full scale engineering development programs to install color CRTs on the F-15E and the C-17 are underway, and the installation of color CRTs on later models of the F-16 and on the advanced tactical fighter is expected. Key performance parameters, such as brightness, contrast, and resolution are discussed. Author

**A87-16744**

## **COVERT PENETRATION SYSTEMS FUTURE STRATEGIC AIRCRAFT MISSIONS WILL REQUIRE A NEW SENSOR SYSTEM APPROACH**

P. A. FLEURY (Rockwell International Corp., Anaheim, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 220-226.

This paper discusses past, present, and future strategic aircraft requirements for ingress and egress, and then focuses on the technologies of the CO2 Laser Radar and the Automatic Target Recognizer (ATR). Present systems currently consist of a mix of various sensors which are not correlated until each is presented to the operator. Additionally, active sensors are highly detectable by threat warning systems, while passive sensors do not provide critical range information. CO2 Laser and ATR technologies will significantly contribute to the resolution of these issues. Author

**A87-16745**

## **ELECTRONICALLY STEERABLE ANTENNA TECHNOLOGY AND ITS APPLICATION TO AIRBORNE RADARS**

T. O. SHAFER (USAF, Directorate of Avionics Engineering, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 228-233.

This paper broadly describes electronically steerable antenna (ESA) technology and its use in airborne radar systems. The methodology in which an antenna is electronically steered is presented first and is illustrated. Phase shifting, a method of electronically controlling an antenna pattern, is presented next, comparing two types of phase shifter technology, ferrite devices and solid state devices. The paper then presents three types of overall airborne radar design which incorporate an ESA: passive, distribute-receive, and active. For each of these, performance, reliability and maintainability trade-offs are presented and overall technology trends are summarized. Author

**A87-16746**

## **OIL SLICK DETECTION WITH AN AIRBORNE SLAR**

F. WITTE (DFVLR, Institut fuer Hochfrequenztechnik, Wessling, West Germany) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 234-239.

In the field of remote sensing and reconnaissance research the German Aerospace Research Establishment (DFVLR) carries out different experiments with different sensors or sensor packages. One of these is the DFVLR-SLAR, an experimental inexpensive side-looking airborne radar operating in X-band. It is used for generation of radar imagery from land and sea surfaces with spatial resolution similar to that of future satellite systems. Depending on the application, the SLAR is flown in different aircraft such as the Cessna 207, Do28, or Do 228. The DFVLR-SLAR was employed during the Archimedes II project (oil slick detection, qualification and classification in the North Sea) on October 1 and 2, 1985. The data collected show the good ability of the SLAR to detect thin oil slicks, of the order of 1 micron or less, on the water's surface. The observed shapes of the slicks are similar to those obtained from an UV and an IR sensor. Author

A87-16747

**ROSAR - A SAR CONCEPT BASED ON ROTATING ANTENNAS**

C. BOESSWETTER and H. KLAUSING (DFVLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofer, West Germany) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 240-245. Research sponsored by Messerschmitt-Boelkow-Blohm GmbH and DFVLR.

In the paper a synthetic aperture radar concept based on antenna rotation, which may find interesting new applications for helicopter mounted short range radar imaging systems, is described. Since the rotor-induced Doppler spectrum is used for imaging only, the system does not require a forward velocity. First design considerations show that a system at mm wave frequencies (35-94 GHz) looks feasible to match the special helicopter requirements and constraints. Since the synthetic apertures are no longer straight lines but circular segments the image formation process requires a polar format processing architecture. If done in real time this would provide an all-sight viewing capability (360 deg). Performance parameters of a first design example are given. Author

A87-16764#

**AF MULTIPROCESSOR FLIGHT CONTROL ARCHITECTURE DEVELOPMENTS CRMMFCS AND BEYOND**

D. B. THOMPSON and R. A. BORTNER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 376-382. refs

This paper discusses the pertinent issues, systems, and concepts leading up to the current work on the Advanced Multiprocessor Control Architecture Definition program. Included is a summary of the benefits and problems associated with the key concepts of the Continuously Reconfiguring Multi-Microprocessor Flight Control System architecture developed by the Flight Dynamics Laboratory from 1980-83. Author

A87-16766\* Sparta Systems, Inc., Laguna Hills, Calif.

**REQUIREMENT ANALYSIS OF AN INTELLIGENT, REDUNDANT, ACTUATION SYSTEM**

P. DE FEO (SPARTA, Inc., Laguna Hills, CA) and K. C. SHIH (NASA, Ames Research Center, Moffett Field, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 391-398. NASA-supported research.

The reliability and fault tolerance requirements of integrated, critical, digital fly-by-wire control systems for advanced military and civil aircraft requires redundant, reconfigurable implementations of the actuation system. An effective way for controlling the actuators and implementing the required fault detection and reconfiguration strategies is by means of dedicated microprocessors. This paper describes a laboratory implementation of a flexible intelligent redundant actuation system capable of demonstrating the concept and analyzing a variety of configurations and technical issues. Author

A87-16807

**RAPID PROTOTYPING OF PILOT INTERFACES AS AN AID TO DEFINING SOFTWARE REQUIREMENTS**

A. ARKUSINSKI and K. HORNBAACH (Lear Siegler, Inc., Instrument Div., Grand Rapids, MI) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1986, p. 828-835. refs

Criteria are defined for a designing prototype user interfaces for evaluating digital avionics displays from the prospective user standpoint. The design goal is to limit the display to necessary data only, provide readable, comprehensible displays, and provide

understandable transitions between screens. Design efforts must consider the size and shape of the screen and entry keys, selection of interaction mechanisms, display character and graphics, sound output, simulation of real-time external inputs, and ease of modification. It is also desirable that the system be portable, usable on a customer's computer, and allow for large-screen displays at conferences. M.S.K.

A87-16836\* Research Triangle Inst., Research Triangle Park, N.C.

**MULTIPURPOSE AIRCRAFT MONITORING WITH A SMART RECORDER**

J. H. WHITE, J. F. FINGER (Research Triangle Institute, Research Triangle Park, NC), and P. J. ALFONSI (NASA, Wallops Flight Center, Wallops Island, VA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1120-1127. (Contract NAS1-16098)

This paper describes a microprocessor-based flight recorder the 'Smart Recorder' - which was developed and installed on a King Air aircraft used for commercial charter service. The recorder is used as a research tool for developing monitoring strategies and processing algorithms to: (1) characterize the typical flight environment encountered by the host aircraft, (2) develop technology for automated engine trend monitoring, and (3) implement a crash recording capability. Initially the recorder was used as an adaptive data acquisition system, monitoring engine sensors and flight instruments and then modifying its data acquisition in response to the perceived aircraft situation. Data collected in this manner were stored in a removable bubble memory and subsequently analyzed in the laboratory. Later, on-board processing was implemented to better utilize the available storage capacity. Author

A87-16839#

**THE B-1B CENTRAL INTEGRATED TEST SYSTEM EXPERT PARAMETER SYSTEM**

G. J. MONTGOMERY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1170-1175.

The B-1B Central Integrated Test System (CITS) provides a comprehensive on aircraft diagnostic capability and records approximately 19,600 parameters. The B-1B CITS Expert Parameter System (CEPS) is an initiative to improve B-1B diagnostic capabilities by applying expert system and data analysis techniques to the in-flight recorded data. The manner in which CEPS enhances B-1B on and off aircraft diagnostic capabilities and reduces false alarm, can not duplicate and re-test okay occurrences will be presented. The CEPS capabilities will be discussed and an overview of the accomplishments and status of the CEPS program will be given. This paper will also illustrate the applicability of the B-1B CEPS concepts to other existing and future weapon systems. The ability to reduce future weapon system built-in test requirements through the use of on-aircraft expert systems will be discussed, along with the need for a ground based diagnostic system. Author

A87-16840

**PILOT'S ASSOCIATE DEMONSTRATION ONE - A LOOK BACK AND AHEAD**

L. D. POHLMANN (Boeing Military Airplane Co., Seattle, WA) and J. R. PAYNE (Advanced Decision Systems, Mountain View, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1176-1183. refs

(Contract F33615-83-C-1083; F33615-83-C-3618)

Progress in the programming of prototype expert systems for military aircraft avionics as part of the Boeing D-1 demonstration program is summarized. The D-1 effort exploits previous pictorial

display format work, AI techniques and existing simulation facilities, and is directed at both air-to-ground and air-to-air combat modes. Implemented on a LISP processor, D-1 incorporates a specific sequence of mission situations considered amenable to expert systems applications. The prototype system architecture is described in terms of a crew station information manager, integration controller, situation assessor and a planner. M.S.K.

## A87-16841

### PILOT'S ASSOCIATE DEMONSTRATION ONE - A LOOK INSIDE

J. B. SHELNUTT, R. O. STENERSON (Boeing Military Airplane Co., Seattle, WA), P. C. NELSON, and P. S. MARKS (Advanced Decision Systems, Mountain View, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1184-1189.

(Contract F33615-83-C-1083; F33615-83-C-3618)

The software architecture used in the Pilot's Associate D-1 program for examining limited prototype expert systems for military avionics systems is described. Attention is also given to the knowledge representation and control techniques applied in a crew station information manager (CSIM). The system architecture comprised a situation assessor, planner, integration controller and the man-machine interface. The components provided mission status, areal IFF functions, battle damage assessment and threat response information. The CSIM was devised to facilitate the interactions between pilots and future avionics systems and to perform situation assessment, route planning and overall systems control, using data from a distributed system architecture.

M.S.K.

## A87-16848

### A MICROPROCESSOR-BASED NOISE CANCELLOR FOR THE COCKPIT

R. VEMULA and E. LEE (Telephonics Corp., Huntington, NY) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1323-1327.

A TMS 320 microprocessor-based noise cancellation circuit has been developed using a lattice filter with proprietary adaptive control mechanism. The circuit has been tested with various real-world noises, such as those generated in UH1H, CH47C, UH60A and Apache helicopters, and also with noises synthesized in the lab, such as power line interference and pink noise. Test results indicate that the circuit provides 6 to 18 dB noise reduction with no perceivable distortions to speech sounds. It is also found that the speech recognition accuracy improves by about 4 to 8 percent due to noise cancellation provided by the circuit.

Author

## A87-17722

### AERIAL PHOTOGRAPHY: AUTOMATION OF AERIAL-PHOTOGRAPHY PROCESSES [AEROFOTOS'EMKA: AVTOMATIZATSIYA AEROFOTOS'EMOCHNYKH PROTSESSOV]

N. P. LAVROVA, I. V. ALMAZOV, and A. N. PRILEPSKII Moscow, Izdatel'stvo Nedra, 1985, 256 p. In Russian. refs

The present work reviews the basic techniques of aerial photographic (AP) aircraft guidance, the elements of AP flight, and the precision with which these elements can be measured and maintained. Aspects of the automation of AP processes are examined along with methods and instruments for fixing the position of aerial photographs in flight. Particular attention is given to the use of AP gyro-stabilizing devices and sidelooking radar. B.J.

## A87-17931#

### STALL MARGIN INDICATOR DEVELOPMENT

A. W. HOADLEY (Western Michigan University, Kalamazoo, MI) and R. S. VANDERBOK (Electronic Systems Development Co., Canton, MI) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 6 p. refs

(AIAA PAPER 86-2694)

The landing and takeoff phases of flight require control of the aircraft at airspeeds and angles of attack close to stall. This is particularly true when a wind shear condition has been encountered. An indication of stall margin gives the pilot required critical information on a real time cockpit display. This paper describes a prototype stall margin indication system. The prototype unit was designed to demonstrate improvements in pressure sensing stability, system versatility, and cockpit integration. Author

## A87-17943#

### A MULTI-PURPOSE AIRBORNE INTEGRATION DISPLAY AND DATA COLLECTION SYSTEM FOR MONITORING JET ENGINES

G. F. FORSYTH (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p. refs

(AIAA PAPER 86-2719)

Data collection systems are comprised of data acquisition and data recording elements. The integration of various elements of these types into reliable data acquisition systems for airborne use can be accomplished using a System Integration and Display (SID) unit. This microprocessor based unit is also capable of encoding the date and time in the data stream to allow for identification of the recording. SID provides display and keyboard features to allow for operating mode selection and for display of selected data or parameters. It also contains a limited amount of non-volatile memory. Author

## A87-17945#

### SYSTEM DESIGN TRENDS IN COMMERCIAL TRANSPORT AIRCRAFT EVOLUTION OR REVOLUTION?

L. F. BATEMAN (Airbus Industrie, Toulouse, France) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p.

(AIAA PAPER 86-2722)

The paper reviews recent and near term development trends in a number of major systems areas, with an emphasis on flight control and flight deck display systems. The benefits that emerging technologies have brought and will bring to the aircraft operator are broadly assessed and significant gains are demonstrated. A conservative approach to the adoption of new technologies is advocated. Whilst the systems proposed for the aircraft which will enter service during the next ten years may appear to represent dramatic changes, relative to those in service at the present time, a logical progression is illustrated. The paper concludes that the development trends in the design of systems for transport aircraft are following an evolutionary path and that a revolutionary approach is neither necessary nor desirable. Author

## A87-17948#

### AUTOMATED THERMAL AND RELIABILITY ANALYSIS OF AVIONICS DESIGNS

J. D. DIRE, D. E. FRANKS, and H. S. CHOI (General Dynamics Corp., Convair Div. and Space Systems Div., San Diego, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 6 p.

(AIAA PAPER 86-2730)

This paper describes a new automated process currently being developed and implemented at General Dynamics Convair/Space Systems Divisions to enhance the reliability of printed circuit boards (PCBs). The process is entitled 'Convair-Computer Aided Reliable Design' (C-CARD) and is used to optimize the component mounting locations on a PCB for thermal reliability. PCB information contained in a computer aided design (CAD) data base is used to automatically

produce a thermal mathematical model for use with the SINDA finite difference heat transfer code. Resulting temperature and reliability predictions are displayed and evaluated by the packaging engineer based on the design requirements. Once the PCB design is optimized for thermal reliability it is then released for manufacture. In this way, the heat-transfer analysis is integrated into the design process and provides the packaging engineer with a thermally safe design in minutes instead of weeks. Author

**A87-17952#**  
**COMPUTER AIDED CREWSTATION INFORMATION ALLOCATION**

M. E. ROWLAND and W. R. WAGONER (Boeing Military Airplane Co., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. (AIAA PAPER 86-2734)

The challenge of designing an effective operator oriented crewstation is being met with a new computer enhanced methodology. Using mission requirements as a spring board, this methodology synthesizes hardware, software, and Human Factors criteria, insuring that all needed mission capabilities are merged into a total Controls and Displays concept. The process was accomplished by developing a computer program which optimizes information allocation to display type and location and control type and location according to several critical parameters assigned by the designer. The result is a crewstation design which logically integrates the multiple outputs of sophisticated avionics in a way that allows high operator efficiency. Initial validation results indicate that the methodology provides a logical flow-down of information requirements into an integrated crewstation design. Author

**A87-17953#**  
**INTERACTIVE DESIGN TOOL FOR COCKPIT CONTROLS AND DISPLAYS DEVELOPMENT**

G. QUALLS (Boeing Military Airplane Co., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. (AIAA PAPER 86-2735)

The architecture of the Virtual Avionics Driver System (VADS) utilized for the development of interactive controls and displays for a crew station is described. The system consists of a portable, user programmable control and display console and a maintenance terminal. The VADS employs a user definable cockpit control language and state tables containing data on the functionality of operator actions. The functions of the switch, task, and data tables are discussed. The hardware of the system performs state table sequencing, command processing, and input/output. I.F.

**A87-18998**  
**MANAGEMENT OF UTILITY SYSTEMS IN THE EXPERIMENTAL AIRCRAFT PROGRAMME**

I. MOIR (Smiths Industries, PLC, Cheltenham, England) and A. G. SEABRIDGE (British Aerospace, PLC, Warton Div., Preston, England) Aerospace (UK) (ISSN 0305-0831), vol. 13, Sept. 1986, p. 28-34. refs

The design of an integrated data processing system for control and management of aircraft utility systems in the European Experimental Aircraft Program is described. Block diagrams are presented of the architecture which emerged for semiautomated control and management of systems such as the engine, fuel and hydraulic systems, environmental systems, secondary power system, etc. Finally, software development techniques which were implemented to realize the project goals in the new hardware are summarized. Demonstration flights are to begin in 1986. M.S.K.

**A87-19069**  
**AVIONICS MAINTENANCE 2010**

D. DOWLING and T. L. RUPINSKI (ARINC Research Corp., Annapolis, MD) IEEE Journal on Selected Areas in Communications (ISSN 0733-8716), vol. SAC-4, Oct. 1986, p. 1090-1096.

This paper postulates an avionics maintenance concept for the year 2010. The concept recognizes the change that is occurring

in new systems toward internal fault isolation using built-in test. Currently, fault isolation data are held in the failed system or within the aircraft computer for subsequent analysis by maintenance personnel. Under the Maintenance 2010 concept, fault data would be analyzed as soon as possible during a mission to identify replacement components needed. A data link from the aircraft to a ground maintenance support system is proposed to permit further diagnosis of faults and to expedite preparation for immediate corrective maintenance action on the flight line when the aircraft returns. The concept is designed to eliminate aircraft down time while awaiting maintenance and thereby improve operational readiness. Author

**A87-19094\*** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**MILLIMETER-WAVE IMAGING SENSOR**

W. J. WILSON, R. J. HOWARD, A. C. IBBOTT, G. S. PARKS, and W. B. RICKETTS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IEEE Transactions on Microwave Theory and Techniques (ISSN 0018-9480), vol. MTT-34, Oct. 1986, p. 1026-1035. refs

A scanning 3-mm radiometer system has been built and used on a helicopter to produce moderate-resolution (0.5 deg) images of the ground. This millimeter-wave sensor can be used for a variety of remote-sensing applications and produces images through clouds, smoke, and dust when visual and IR sensors are not usable. The system is described and imaging results are presented. Author

**A87-19282**  
**A MODULAR FLIGHT CONTROL AND NAVIGATION SYSTEM FOR THE NEXT GENERATION OF ARMY AVIATION**

C. T. BYE, J. T. BAKKEN, and S. I. SNYDER (Honeywell, Inc., Minneapolis, MN) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1079-1089.

Unprecedented demands will be placed on the flight control and navigation equipment of the next-generation of Army helicopters to enable single crewmember operability in tactical environments. These demands require a degree of automation, and assurance of a level of pilot confidence not yet achieved on conventional present-generation vehicles. Trade studies have been performed concerning the significant issues involved in developing an optimum system architecture. The resulting architecture maximizes the sharing of sensor and computational resources in a flight-critical environment, and employs modular equipment packaging, dual fault-tolerant tetrad ring laser gyro inertial measurement units, and triplex self-checking processor pair-based flight critical processing channels. Author

**A87-19283**  
**SYSTEM SENSORY PERCEPTION (SSP)**

H. A. BECKER (IBM Corp., Federal Systems Div., Owego, NY) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1091-1095.

Design considerations for future helicopter sensor suites are presented. The avionics generation projected will employ high speed parallel processors capable of billions of operations/sec, as well as the processing of hundreds on Mybytes of global memory. This processing capability will make military operations possible at night, in adverse weather, and with one-man crews, on the basis of the advanced sensor inputs presently considered. Technology development in laser systems leading to higher laser efficiencies is noted to be of fundamental importance in sensor development. O.C.

## A87-19284

### SHADOW

P. J. EMIRO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1097-1102.

SHADOW is an experimental helicopter, based on an S-76A, that is exploring the functional, automation and integration requirements necessary for single-pilot operation of future military rotorcraft. This paper describes the physical aircraft, its flight controls and the avionics that support the workload experiments. Even with the added weight and drag of the single pilot cockpit, SHADOW has maintained nearly all the original S-76A performance. The avionics, linked by a MIL-STD 1553B data bus, has demonstrated the capability and potential of a highly integrated system. The fly-by-wire flight controls yield a variable stability aircraft whose handling qualities are optimized on the basis of instantaneous aircraft conditions and pilot input. Using an advanced data collection/experiment control, quantitative data is collected to aid analysis of experiment results. Author

## A87-19285

### HH-60 AVIONICS - A PROGRESS REPORT

C. RICHARDSON (IBM Corp., Owego, NY) and R. LAMBDAIN (USAF, Rescue and Special Operations Directorate, Wright-Patterson AFB, OH) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1103-1111. refs

The avionics system of the HH-60A Night Hawk is described, together with the results of the development and test efforts. The core elements of the HH-60 avionics system include redundant central processing, using dual MIL-STD-1750 computers, and a redundant MIL-STD-1553 data bus, with all equipment interfaced to the bus either directly or through Remote Terminal Units. The highly integrated cockpit reduces crew workload and permits aircraft operation by a pilot and copilot without a flight engineer. I.S.

## A87-19289

### V-22 AVIONICS METHODOLOGY AND DESIGN

R. KLIPPERT (IBM Corp., Owego, NY) and E. KEY (Boeing Military Aircraft Co., Wichita, KS) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, 3 p.

Attention is given to the design features and performance capabilities of the V-22's avionics system hardware and software elements. Software encompasses communication-identification, mission management, and test module monitoring; hardware prominently includes four multifunction displays driven by two display processors, two control display units, and a dual helmet-mounted display. Attention is given to the two-company development program management aspects of V-22 avionics endeavors. O.C.

## A87-19355#

### OMEGA ACCESS - A MICROCOMPUTER DISPLAY OF OMEGA SIGNAL COVERAGE DIAGRAM

R. S. WARREN, K. A. TENCH, R. R. GUPTA (Analytic Sciences Corp., Reading, MA), and P. B. MORRIS (OMEGA Navigation System Operations Detail, Washington, DC) IN: Institute of Navigation, Annual Meeting, 42nd, Seattle, WA, June 24-26, 1986, Proceedings. Washington, DC, Institute of Navigation, 1986, p. 26-31.

This paper describes a new and unique presentation medium for OMEGA signal coverage diagrams using available microcomputers. It is now not only possible, but highly desirable, to distribute OMEGA coverage information in a computer (electronic) format and to have interactive tools at the fingertips of users and engineers which enable them to access and display coverage diagrams approved for publication by ONSOD (OMEGA Navigation System Operations Detail). The OMEGA automated composite coverage evaluator of system signals (OMEGA ACCESS)

provides this new dimension to the presentation of the complex coverage information. The effective use of color with pop-up menus and a user-friendly interface allows anyone with access to an IBM PC, XT or AT (or equivalent) the capability to explore a wide range of 'what if' questions. In addition to being a new and powerful OMEGA system support tool for the navigation community, OMEGA ACCESS also provides new coverage information for reduced power conditions. Author

## A87-19414#

### INSTRUMENTATION FOR RCS MEASUREMENTS OF MODULATION SPECTRA OF AIRCRAFT BLADES

G. G. FLISS and D. L. MENSA (U.S. Navy, Pacific Missile Test Center, Point Mugu, CA) IN: National Radar Conference, Los Angeles, CA, March 12, 13, 1986, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 95-99.

This paper describes the implementation of an instrumentation system for measuring spectral signatures of rotating aircraft blades. The objective of the system is to measure spectral signatures in terms of their absolute radar cross section. Suitable for measuring stationary vehicles with rotating propulsion and lift systems, the coherent CW heterodyne system is assembled using commercially available instruments and components. The unique feature of the implementation is the ability to measure low Doppler frequencies from structures which are rotated at very low rates. When coupled with a modern digital signal analyzer, complex modulation spectra of the object signature can be displayed rapidly and accurately. Examples of spectral signatures, obtained from laboratory and field measurements on helicopter rotating assemblies, are presented to demonstrate the capabilities of the system. Author

N87-13438\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### DEVELOPMENT AND EVALUATION OF AN AIRPLANE ELECTRONIC DISPLAY FORMAT ALIGNED WITH THE INERTIAL VELOCITY VECTOR

G. G. STEINMETZ Dec. 1986 23 p  
(NASA-TP-2648; L-16168; NAS 1.60:2648) Avail: NTIS HC A02/MF A01 CSCL 01D

The development of an electronic primary flight display format aligned with the aircraft velocity vector, a simulation evaluation comparing this format with an electronic attitude-aligned primary flight display format, and a flight evaluation of the velocity-vector-aligned display format are described. Earlier tests in turbulent conditions with the electronic attitude-aligned display format had exhibited unsteadiness. A primary objective of aligning the display format with the velocity vector was to take advantage of a velocity-vector control-wheel steering system to provide steadiness of display during turbulent conditions. Better situational awareness under crosswind conditions was also achieved. The evaluation task was a curved, descending approach with turbulent and crosswind conditions. Primary flight display formats contained computer-drawn perspective runway images and flight-path angle information. The flight tests were conducted aboard the NASA Transport Systems Research Vehicle (TSRV). Comparative results of the simulation and flight tests were principally obtained from subjective commentary. Overall, the pilots preferred the display format aligned with the velocity vector. Author

N87-13439# Analytic Sciences Corp., Reading, Mass.  
**INTEGRATED COMMUNICATION, NAVIGATION, AND IDENTIFICATION AVIONICS RESOURCE ALLOCATION Final Report, Mar. 1982 - Mar. 1984**

B. E. GRIFFITHS and D. E. MILLER Jul. 1986 30 p  
(Contract F33615-82-C-0002)  
(AD-A170357; AFHRL-TR-86-10) Avail: NTIS HC A03/MF A01 CSCL 09C

The Integrated Communication, Navigation, and Identification Avionics (ICNIA) architecture is being designed to replace a number of discrete avionics components with an integrated, modular system. In order to maximize the usefulness of ICNIA-supported functions, a new resource allocation technique is needed. This report presents a preliminary assessment of several methods of

reallocation and describes measures of performance for all of these techniques. Author (GRA)

07

## AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

**N87-13440#** Physikalisch-Technische Bundesanstalt, Brunswick (West Germany). Abteilung Akustik.

**INVESTIGATION OF THE ELECTROACOUSTIC PROPERTIES OF COCKPIT RECORDERS AND COCKPIT AREA MICROPHONES IN PASSENGER AIRCRAFT [UNTERSUCHUNG DER ELEKTRO-AKUSTISCHEN EIGENSCHAFTEN VON COCKPIT-VOICE-RECORDERN UND COCKPIT-AREA-MIKROFONEN AUS VERKEHRSFLUGZEUGEN]**

A. THIEL Feb. 1986 41 p In GERMAN  
(PTB-AK-30; ISSN-0340-8639; ETN-86-98201) Avail: NTIS HC A03/MF A01

The electroacoustic properties of two cockpit voice recorders used for magnetic tape records of aircraft accidents, which are often perturbed by background noise, were studied. An older and a more recent type of recorder and three standard cockpit-area microphones were used. In order to evaluate the quality of the signals registered on the magnetic tape, the frequency response of the monitoring amplifier including the playback head, the frequency response between recording input and monitoring output, and the free-field frequency response of the microphone were determined. The frequency band of the old recorder is only between 300 Hz to 3 kHz; the newer one between 200 Hz and 5 kHz. Both recorders have an imperfect head-band contact. The older recorder shows echo effects and an insufficient voltage adaptation to the microphone. ESA

**N87-14329** Singer-Link-Miles Ltd., Lancing (England).  
**A SIMULATED INSTRUMENT, SERIAL BUS SYSTEM Final Report**

D. P. ALLSOP and L. G. MARINI 30 Aug. 1986 106 p  
(Contract MOD-A85A/393)  
(LM/TR/654/2/2; ETN-86-98357) Avail: Issuing Activity

The feasibility of a bus system to interconnect simulated aircraft instruments was assessed. Instrument uses, serial bus types, and methods of implementation were studied. An approach which employs master-slave serial buses associated with each main group of software modules is presented. ESA

**N87-14330\*#** Boeing Commercial Airplane Co., Seattle, Wash.  
**TEST AND EVALUATION OF A MULTIFUNCTION KEYBOARD AND A DEDICATED KEYBOARD FOR CONTROL OF A FLIGHT MANAGEMENT COMPUTER Final Report**

J. M. CRANE, G. P. BOUCEK, JR., and W. D. SMITH Nov. 1986 122 p  
(Contract NAS1-17635)  
(NASA-CR-178202; NAS 1.26:178202) Avail: NTIS HC A06/MF A01 CSCL 01D

A flight management computer (FMC) control display unit (CDU) test was conducted to compare two types of input devices: a fixed legend (dedicated) keyboard and a programmable legend (multifunction) keyboard. The task used for comparison was operation of the flight management computer for the Boeing 737-300. The same tasks were performed by twelve pilots on the FMC control display unit configured with a programmable legend keyboard and with the currently used B737-300 dedicated keyboard. Flight simulator work activity levels and input task complexity were varied during each pilot session. Half of the points tested were previously familiar with the B737-300 dedicated keyboard CDU and half had no prior experience with it. The data collected included simulator flight parameters, keystroke time and sequences, and pilot questionnaire responses. A timeline analysis was also used for evaluation of the two keyboard concepts. Author

**A87-17599**

**THE DYNAMICS OF GAS TURBINE ENGINE COMPONENTS IN THE PRESENCE OF DAMAGE [DINAMIKA ELEMENTOV GAZO-TURBINNYKH DVIGATELEI PRI NALICHII POVREZHDENII]**

I. F. OBRAZTSOV, A. S. VOLMIR, and A. E. TIKHOMIROV  
Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 289, no. 6, 1986, p. 1329-1331. In Russian. refs

A study is made of the dynamic characteristics of the individual components of gas turbine engines having cracks of varying length and different orientations. The modes and frequencies of such components are determined and compared with the parameters of the corresponding damage-free structures. In particular, results are presented for a defect-free turbine blade, a turbine blade with a transverse crack, and a turbine blade with a longitudinal crack. V.L.

**A87-17813#**

**EXPERIMENTAL STUDY OF TURBOSHAFT ENGINE CORE NOISE**

A. GUEDEL (ONERA, Chatillon-sous-Bagneux, France) and A. FARRANDO (Turbomeca, S.A., Bordes, France) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 763-767. Research sponsored by the Service Technique des Programmes Aeronautiques. refs

An experimental method is presented for locating the sources contributing to the low-frequency (0-5 kHz) broadband noise of a turboshaft engine. This method is based on a three-signal coherence technique using the signals of two internal probes in a section of the engine and of an external microphone placed in either the near or far field. The principle of the method is not new, but it seems never to have been applied before for turboshaft core noise source separation. Author

**A87-17839#**

**BORON SLURRY-FUELED JET ENGINE EXHAUST PLUME INFRARED SIGNATURES**

H. F. NELSON and E. O. TUCKER (Missouri-Rolla, University, Rolla) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Sept.-Oct. 1986, p. 527-533. Research supported by the McDonnell Douglas Astronautics Co. Previously cited in issue 07, p. 848, Accession no. A86-19888. refs

**A87-17880#**

**PROPULSION CHALLENGES FOR HYPERSONIC FLIGHT**

L. L. COONS (Pratt and Whitney, Engineering Div., West Palm Beach, FL) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. (AIAA PAPER 86-2620)

The present evaluation of a generic airbreathing propulsion system for hypersonic vehicles projects revolutionary performance capabilities and economies in either earth-to-orbit booster or hypersonic cruiser missions. The design features of inlet and nozzle systems are noted to be critical for successful operation, and require geometries that are integrated with vehicle aerodynamic contours and primary structures. Fuel selection affects not only propulsion system performance but the capacity for both propulsion and vehicle systems cooling. O.C.

## **A87-17934\*#** Beech Aircraft Corp., Wichita, Kans. **APPLICATION OF PROPFAN PROPULSION TO GENERAL AVIATION**

R. W. AWKER (Beech Aircraft Corp., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 16 p. refs  
(Contract NAS3-24349)  
(AIAA PAPER 86-2698)

Recent studies of advanced propfan propulsion systems have shown significant reductions in fuel consumption of 15-30 percent for transport class aircraft. This paper presents the results of a study which examined applying propfan propulsion to General Aviation class aircraft to determine if similar improvements could be achieved for business aircraft. In addition to the potential performance gains, this paper also addresses the cost aspects of propfan propulsion on General Aviation aircraft emphasizing the significant impact that the cost of capital and tax aspects have on determining the total cost of operation for business aircraft.

Author

## **A87-17937#** **TURBOFAN ENGINE CYCLE DESIGN SELECTION - YEAR 2000**

R. B. STEINMETZ and M. J. WAGNER (General Electric Co., Cincinnati, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p.  
(AIAA PAPER 86-2705)

To define the optimum turbofan engine cycle for the year 2000, a parametric study was undertaken to define candidate engine thermodynamic cycles for advanced long range aircraft. Performance comparisons are based on uninstalled cruise specific fuel consumption (SFC). A base cycle design with current state-of-the-art technology was established as a reference. A parametric study was then conducted where component technologies projected for the year 2000 were included in the cycle design process. As bypass ratio increased, the transition from direct drive to geared fans was accounted for. Separate versus mixed flow exhaust systems were also studied. An uninstalled SFC improvement of approximately 18 percent was found for the year 2000 turbofan relative to the baseline engine.

Author

## **A87-17993\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **AN OVERVIEW OF THE SMALL ENGINE COMPONENT TECHNOLOGY (SECT) STUDIES**

M. R. VANCO, W. T. WINTUCKY, and R. W. NIEDWIECKI (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 19 p. Previously announced in STAR as N86-31587. refs  
(AIAA PAPER 86-1542)

The objectives of the joint NASA/Army SECT studies were to identify high payoff technologies for year 2000 small gas turbine engine applications and to provide a technology plan for guiding future research and technology efforts applicable to rotorcraft, commuter and general aviation aircraft and cruise missiles. Competitive contracts were awarded to Allison, AVCO Lycoming, Garrett, Teledyne CAE and Williams International. This paper presents an overview of the contractors' study efforts for the commuter, rotorcraft, cruise missile, and auxiliary power (APU) applications with engines in the 250 to 1,000 horsepower size range. Reference aircraft, missions and engines were selected. Advanced engine configurations and cycles with projected year 2000 component technologies were evaluated and compared with a reference engine selected by the contractor. For typical commuter and rotorcraft applications, fuel savings of 22 percent to 42 percent can be attained. For \$1/gallon and \$2/gallon fuel, reductions in direct operating cost range from 6 percent to 16 percent and from 11 percent to 17 percent respectively. For subsonic strategic cruise missile applications, fuel savings of 38 percent to 54 percent can be achieved which allows 35 percent to 60 percent increase in mission range and life cycle cost reductions of 40 percent to

56 percent. High payoff technologies have been identified for all applications.  
Author

## **A87-18117** **ENERGY CONVERSION FOR LONG ENDURANCE AIR VEHICLES**

C. LAVAN (Goodyear Aerospace Corp., Defense Systems Div., Akron, OH) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3. Washington, DC, American Chemical Society, 1986, p. 1703-1707. refs

Long endurance aircraft for surveillance and communications missions in the civil and military sectors require an integrated approach to the generation and utilization of power for the electrical energy needs of the vehicle. A technique is proposed which results in the identification of dimensionless parameters which express the ratios of design-related physical parameters in much the same way that the Reynold's number characterizes the ratio of inertial to viscous forces in fluid mechanics. Parameters have been derived which characterize the power generation and distribution systems in terms of dependent and independent variables appropriate to long endurance aircraft. Quantization of physical parameters in terms of nondimensional relationships leads then to a design methodology based on an integrated approach to power and prime-mover systems.

Author

## **A87-18510** **ANATOMY OF A NEW HELICOPTER ENGINE - PRATT AND WHITNEY CANADA PW200 SERIES TURBOSHAFTS**

K. A. GOOM (Pratt and Whitney Canada, Longueuil) Vertiflite (ISSN 0042-4455), vol. 32, Sept.-Oct. 1986, p. 20-23.

The design of the PW 200 turboshaft engine is described. The layout of the gas path is examined; the positions of the air intake and the combustion chamber are studied. The use of an uncooled compressor turbine in the engine design is discussed. The weight, reliability, life, installability, and cost of the engine were considered during the preliminary designing of the engine components. The advantages of forged compressor turbine disks and separated cast blades are analyzed. The effects of turbine tip clearances on cycle efficiency are investigated. The gearbox of the engine was developed with features such as an over-running clutch, carbon seals, and a phase-shift torque-meter system to improve the reliability and durability of the engine.

I.F.

## **A87-18512** **PLANNING FOR T800-LHT-800 AVAILABILITY, SUPPORTABILITY AND AFFORDABILITY**

K. BULT and W. L. WALLACE (Garrett Turbine Engine Co., Phoenix, AZ) Vertiflite (ISSN 0042-4455), vol. 32, Sept.-Oct. 1986, p. 30-33.

The integration of reliability, availability, and maintainability; integrated logistics support; and manpower and personnel activities in the design and development of the T800-LHT-800 engine is discussed. The basic features of the 1200 shaft horsepower engine developed for military use are described. The two-level maintenance program for the engine, aviation user and depot-level maintenance, are examined.

I.F.

## **A87-18531#** **THE EFFECT OF CASING TREATMENT ON THE PERFORMANCE AND FLOWFIELD IN AXIAL COMPRESSORS**

P. ZHUANG and Y. LU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Aug. 1986, p. 363-370. In Chinese, with abstract in English.

An axial-flow compressor rotor was tested in detail with a solid casing and three types of skewed slot casing. It has been found that skewed slot casing has a great effect not only on the overall performance of a compressor, but also on the type of rotating stall, the spatial propagation, the development of the stall cell and the flowfield behind rotor. The experimental results in this paper are valuable for the establishment of a three dimensional model of rotating stall, the exploitation of a new function of casing



treatment and the practical applications of casing treatment in aviation industry. Author

**A87-19280**

## CRITICAL PROPULSION SYSTEM PARAMETERS FOR FUTURE STOVL COMBAT AIRCRAFT

R. M. DENNING and N. A. MITCHELL (Rolls-Royce, Ltd., Bristol, England) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1047-1056. Research supported by the Ministry of Defence (Procurement Executive). refs

Short Take Off and Vertical Landing (STOVL) aircraft provide a special challenge to the engine designer in that nearly all aspects of propulsion system definition are functions not only of the aircraft design mission but also of the aircraft/engine configuration employed to achieve the STOVL role. The influence that propulsion system parameters (i.e., cycle, rating philosophy, mechanical design and special STOVL features) have on weight and performance of both the engine and aircraft is examined in order to identify critical technology features, and to determine their sensitivity to the total weapons system design. Author

**N87-13443\*#** ISTAR, Inc., Santa Monica, Calif.

## DETONATION WAVE COMPRESSION IN GAS TURBINES Final Contractor Report

A. WORTMAN Dec. 1986 77 p

(Contract NAS3-24854)

(NASA-CR-179557; NAS 1.26:179557) Avail: NTIS HC A05/MF A01 CSCL 81D

A study was made of the concept of augmenting the performance of low pressure ratio gas turbines by detonation wave compression of part of the flow. The concept exploits the constant volume heat release of detonation waves to increase the efficiency of the Brayton cycle. In the models studied, a fraction of the compressor output was channeled into detonation ducts where it was processed by transient transverse detonation waves. Gas dynamic studies determined the maximum cycling frequency of detonation ducts, proved that upstream propagation of pressure pulses represented no problems and determined the variations of detonation duct output with time. Mixing and wave compression were used to recombine the combustor and detonation duct flows and a concept for a spiral collector to further smooth the pressure and temperature pulses was presented as an optional component. The best performance was obtained with a single firing of the ducts so that the flow could be re-established before the next detonation was initiated. At the optimum conditions of maximum frequency of the detonation ducts, the gas turbine efficiency was found to be 45 percent while that of a corresponding pressure ratio 5 conventional gas turbine was only 26%. Comparable improvements in specific fuel consumption data were found for gas turbines operating as jet engines, turbofans, and shaft output machines. Direct use of the detonation duct output for jet propulsion proved unsatisfactory. Careful analysis of the models of the fluid flow phenomena led to the conclusion that even more elaborate calculations would not diminish the uncertainties in the analysis of the system. Feasibility of the concept to work as an engine now requires validation in an engineering laboratory experiment.

Author

**N87-13444#** Minnesota Univ., Minneapolis. Heat Transfer Lab. STUDIES OF GAS TURBINE HEAT TRANSFER: AIRFOIL SURFACE AND END-WALL Annual Progress Report, 3 Jan. 1985 - 28 Feb. 1986

E. R. ECKERT, R. J. GOLDSTEIN, and T. W. SIMON Apr. 1986 74 p

(Contract F49620-85-C-0049)

(AD-A172470; AFOSR-86-0854TR) Avail: NTIS HC A04/MF A01 CSCL 21E

The annual report documents progress at the University of Minnesota Heat Transfer Laboratory on the topic of heat transfer from gas turbine airfoil and end-wall surface. Subtopics are: Curvature effects, End-wall heat transfer and Near-end-wall heat

transfer. Curvature effects on turbulent transport are shown for a smooth convex wall and for single-row film-cooled convex and concave walls. End-wall mass (heat) transfer coefficient contours show the horseshoe vortex, the passage vortex and an inner vortex. GRA

**N87-14331#**

Stuttgart Univ. (West Germany).

Sonderforschungsbereich 85.

## THERMODYNAMIC AND FLOW MECHANICAL PROBLEMS IN AIRCRAFT AND SPACECRAFT DRIVES Final Report, 1972-1985 [THERMODYNAMISCHE UND STROMUNGSMCHANISCHE PROBLEME DER LUFT- UND RAUMFAHRTANTRIEBE]

Apr. 1986 459 p In GERMAN

(ETN-87-98751) Avail: NTIS HC A20/MF A01

Laser interferometry; reaction kinetics study in exhaust gases by mass spectrometry, Raman spectroscopy and electron beams; and concentration and relaxation times measurements are discussed. Flow and combustion processes, and numerical calculation methods are considered, including jet mixing flow, compressor blade profile and supersonic cascade design; flow computation in counter-rotating cascades, in chemically reacting flows, in three-dimensional cascade flow, and in multistage turbomachines. The effect of Reynolds number on turbomachines is investigated. Combined chemical propulsion systems are analyzed.

ESA

**N87-14344#** Stuttgart Univ. (West Germany). Inst. fuer Raumfahrtantriebe.

## TRANSONIC AND SUPERSONIC COMPRESSORS [TRANSCHALL- UND UEBERSCHALLVERDICHTER]

H. H. FRUEHAUF In its Thermodynamic and Flow Mechanical Problems in Aircraft and Spacecraft Drives p 337-367 Apr. 1986 In GERMAN Previously announced as N83-34836

Avail: NTIS HC A20/MF A01

Methods for flow computation in multistage turbocompressors operating in the transonic and supersonic domain were developed. Aerodynamic calculation methods are reviewed. Theory and numerical solution methods of the meridional, azimuthal, quasi-three-dimensional, and fully three-dimensional flow models are presented. Two and three-dimensional boundary layer integral methods are shown. ESA

**N87-14349\*#** Garrett Turbine Engine Co., Phoenix, Ariz.

## SCALED CENTRIFUGAL COMPRESSOR PROGRAM Final Report

G. CARGILL and C. LINDER 31 Oct. 1986 202 p

(Contract NAS3-23277; DA PROJ. 1L1-62209-AH-76)

(NASA-CR-174912; NAS 1.26:174912; USAAVSCOM-TR-85-C-13; GARRETT-21-5464) Avail: NTIS HC A10/MF A01 CSCL 21E

Centrifugal compressors were provided to be used to evaluate the effects of direct scaling, and establishing the methodology for design adjustment when direct scaling is not mechanically feasible. These objectives were accomplished by the following approaches: (1) scaling an existing high-performance centrifugal compressor from 10-lb/sec to 2-lb/sec flow size; (2) making the necessary adjustments to the 2-lb/sec flow size compressor to make it mechanically acceptable; (3) directly scaling the final 2-lb/sec flow size compressor to 10-lb/sec flow size; and (4) fabricating the resulting 10-lb/sec and 2-lb/sec flow size compressors for testing in the NASA-Lewis Compressor Facilities. Author



## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

**A87-16758#****IMPACT OF DISPLAY DYNAMICS ON FLYING QUALITIES**

L. B. MCCORMACK and F. L. GEORGE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 333-338. refs

Air Force Flight Dynamics Laboratory research investigating pursuit display dynamics, identifying characteristic parameters, and determining what values for these parameters aid the pilot, has produced some preliminary results. Although still in its early stages, results of this research show that certain cockpit pursuit display parameters do greatly influence the pilot's performance and work load. These results suggest the flight control designer should incorporate this information earlier in the preliminary aircraft design process. Author

**A87-16759****COMPUTER-AIDED PROCEDURES FOR ANALYZING PILOT/VEHICLE/SYSTEM INTERACTIONS**

R. W. ALLEN, D. T. MCRUER, R. E. MAGDALENO, and H. R. JEX (Systems Technology, Inc., Hawthorne, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 339-348. refs

(Contract F33615-84-C-3625)

This paper describes microcomputer based procedures that are being developed to handle a wide range of dynamic systems analysis and integration problems. The methodology and computational aids will be useful for both military and civilian aircraft systems design, and will apply to other human operator problems such as ground vehicle control. The methodology is designed to provide the user with a practical, systematic approach for the design and analysis of dynamic systems. The microcomputer procedures include a module which allows dynamic system equations of motion to be simply specified, and algorithms for deriving factored transfer functions from linear system dynamics matrices. The software will also link to currently available control systems analysis software which provides frequency domain analysis, plotting procedures and time history capabilities. Author

**A87-16760****THE PILOT WORKLOAD FACTOR IN AIRCRAFT HANDLING QUALITIES ASSESSMENT**

J. S. WARNER and E. D. ONSTOTT (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 349-354. Research supported by the Northrop Independent Research and Development Program.

Pilot task loading is a recognized factor in flight sequences resulting in loss of control. An examination of the Cooper-Harper Rating Scale indicates that pilot workload is a dominant influence in the assignment of Pilot Opinion Ratings. An analytical model is constructed to investigate the interference effects of multiple piloted control tasks, including multi-axis control and side task intrusions. This methodology is applied to an example scenario involving a landing approach task with a Class IV vehicle operating in the presence of severe turbulence. Author

**A87-16761****SAFETY OF FLIGHT ISSUES FOR AN AUTOMATIC TRAJECTORY CONTROL SYSTEM**

M. E. BISE and R. A. LUHRS (Lear Siegler, Inc., Astronics Div., Dayton, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 356-359.

A revised definition of safety of flight, the discovery of underlying safety issues, and the development of candidate safety criteria for an automatic trajectory control system (ATCS) are presented. Flight safety, based on the revised definition, must be separated into distinct control, flight, and mission critical components. The effects of these components on functional partitioning and design for fault tolerance is discussed. In addition, safety issues are presented which now must address new methods of verification and validation and the design criteria embodied in the MIL-SPECS and MIL-STDs. Author

**A87-16767\*** Alphatech, Inc., Burlington, Mass.**INVESTIGATION OF AN AUTOMATIC TRIM ALGORITHM FOR RESTRUCTURABLE AIRCRAFT CONTROL**

J. WEISS, J. ETERNO, D. GRUNBERG, D. LOOZE (Alphatech, Inc., Burlington, MA), and A. OSTROFF (NASA, Langley Research Center, Hampton, VA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 400-406. refs

(Contract NAS1-17411)

This paper develops and solves an automatic trim problem for restructurable aircraft control. The trim solution is applied as a feed-forward control to reject measurable disturbances following control element failures. Disturbance rejection and command following performances are recovered through the automatic feedback control redesign procedure described by Looze et al. (1985). For this project the existence of a failure detection mechanism is assumed, and methods to cope with potential detection and identification inaccuracies are addressed. Author

**A87-16768****DESIGN OF DYNAMIC COMPENSATORS VIA EIGENSTRUCTURE ASSIGNMENT WITH FLIGHT CONTROL APPLICATIONS**

K. M. SOBEL (Lockheed California Co., Burbank, CA) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 408-414. refs

The eigenstructure assignment flight control design methodology is extended to include dynamic compensator synthesis. Dynamic compensators may be designed via eigenstructure assignment by utilizing a composite system structure. The success of this design methodology depends upon proper choice of the desired eigenvectors. An example of the lateral dynamics of an L-1011 aircraft are presented to illustrate the design method. Author

**A87-16769#****LQG/LTR DESIGN OF A FLIGHT CONTROLLER FOR A SHORT TAKE-OFF AND LANDING AIRCRAFT**

G. L. GROSS, R. A. HOUSTON, and P. S. MAYBECK (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 415-420. refs

Two robust controllers for a STOL vehicle are developed via LQG/LTR methods. One of these controllers is developed for maneuvers at altitude and the other is for the approach and landing phase. Reduced-order full-state feedback controllers are synthesized using CGT/PI synthesis, specifically using implicit model following to provide good robustness characteristics in the

full-state feedback case. The robustness is fully assessed using realistic simulations with meaningful deviations from design conditions. Once a Kalman filter is embedded in the loop to estimate states (rather than assuming artificial access to all states), LTR methodology is used to preserve as much robustness as possible. A full assessment of performance and robustness of these final implementable designs is provided. Author

**A87-16770****LONGITUDINAL CONTROL REQUIREMENTS FOR STATICALLY UNSTABLE AIRCRAFT**

H. BEAUFRERE and S. SOEDER (Grumman Aerospace Corp., Bethpage, NY) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 421-433. (Contract F33615-84-C-3604)

Longitudinal control requirements are defined for statically unstable aircraft in terms of open- and closed-loop design parameters using classical frequency domain techniques. Design guides are presented for determining the effect that control loop hardware elements have on stability margins and closed-loop flying qualities. Loop elements containing transport delays are shown to be the most limiting factor on the amount of instability a configuration can have. Author

**A87-16771****DESIGN OF ADAPTIVE DIRECT DIGITAL FLIGHT-MODE CONTROL SYSTEMS INCORPORATING RECURSIVE STEP-RESPONSE MATRIX IDENTIFIERS FOR HIGH-PERFORMANCE AIRCRAFT**

B. PORTER and A. MANGANAS (Salford, University, England) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 434-439. refs (Contract AF-AFOSR-85-0208)

**A87-16772****ROBUST CONTROLLER DESIGN FOR A SHORT TAKE-OFF AND LANDING (STOL) AIRCRAFT USING QUANTITATIVE FEEDBACK THEORY**

B. T. CLOUGH, I. HOROWITZ, and C. HOUPIIS (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 440-447. refs

A robust controller is designed for the longitudinal axes of a STOL vehicle using Quantitative Feedback Theory (QFT). Application of QFT results in fixed compensation providing control for large plant uncertainty arising out of various control surface failures over three flight conditions. Independent control of the forward velocity and angle of attack (direct lift control) is achieved without excess control surface deflections for most cases. Such robust controllers are candidates for the Self Repairing Flight Control System for future aerospace vehicles. Author

**A87-16774****ROBUST CONTROL LAW DESIGN OF AN UNMANNED RESEARCH VEHICLE**

R. RAVULA and K. S. RATTAN (Wright State University, Dayton, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 465-471. Research supported by Wright State University. refs

(Contract F49620-82-C-0035)

In this paper high-gain error-actuated design method is used to design a robust control law for the Unmanned Research Vehicle (URV). The concept of uniform and independent stability margins is then used to analyze the robustness of the system designed.

The stability margins are utilized to specify the regions of stability in both the gain and phase space regions. Author

**A87-16780#****AFTI/F-16 PROGRAM - PHASE II OVERVIEW AUTOMATED MANEUVERING ATTACK SYSTEM**

D. H. ROSS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 534-537.

**A87-16849****AN INTEGRATED VEHICLE MANAGEMENT SYSTEM CONCEPT FOR MILITARY TRANSPORT**

T. E. YOPS, JR. and J. R. MOORE (Boeing Military Airplane Co., Wichita, KS) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1328-1334. USAF-sponsored research. refs

Design techniques and test systems required for the development of an integrated vehicle management system (IVMS) for advanced aircraft are discussed. An integrated approach could eliminate in-flight conflicts between separately-designed flight-critical systems such as guidance and control, mission management, trajectory generation, and command/stability augmentation controllers in a forward-swept wing aircraft. Tests on a NASA 737 aircraft demonstrated the efficiency benefits which accrue from integration of the throttle and autopilot systems to obtain a system which did not run at constant throttle. Features of the Air Force Systems C-135C flight deck systems tested are delineated. M.S.K.

**A87-16853****FLIGHT TEST RESULTS OF A CONTROL ELEMENT FAILURE DETECTION AND ISOLATION ALGORITHM**

J. L. WEISS (ALPHATECH, Inc., Burlington, MA), J. M. STIFEL (General Electric Co., Aircraft Control Systems Dept., Binghamton, NY), and K. S. GOVINDARAJ (Calspan Corp., Buffalo, NY) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1393-1399. refs

Results are reported from flight tests of a system impairment detection and classification algorithm (SIDC) modified to run on a total in-flight simulator vehicle. The test aircraft had side force generating surfaces and independently controllable direct lift flaps outboard of the engine nacelles on the wings. A second cockpit had the capability of simulating failures and monitoring data generated by the SIDC. Emphasis is placed on the detection and identification of control authority failures caused by a partially missing control surface, a condition requiring active reconfiguration in any aircraft. Tests confirmed the robustness of the SIDC in the face of failures which do not affect detectability and for a low level of flap usage. M.S.K.

**A87-17433****DETERMINING THE KINEMATIC PARAMETERS OF A MOVING IMAGING SENSOR BY PROCESSING SPATIAL AND TEMPORAL INTENSITY CHANGES**

H. ZINNER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Optical Society of America, Journal, A: Optics and Image Science (ISSN 0740-3232), vol. 3, Sept. 1986, p. 1512-1517. Research supported by the Bundesministerium der Verteidigung. refs

A method is presented that determines the motion parameters of an imaging sensor by evaluating the spatial and temporal intensity changes in the image plane. If the environment in the field of view is described parametrically, constraint equations between the kinematic parameters and the intensity changes can be derived. Linear solutions of these equations are the so-called pure parameters, which are nonlinear functions of the motion parameters. These quantities are the roll, pitch, and yaw rate, the

angle of attack and the angle of yaw, and orientation parameters. They can be obtained directly by solving a 3 x 3 eigenvalue problem. The algorithm was implemented and applied to artificial and natural image sequences. An error and covariances analysis shows that the method is robust and accurate enough for autonomous navigation. Author

**A87-17564**

## **CONTROLLING THE ELASTIC VIBRATIONS OF AIRCRAFT STRUCTURES BY MEANS OF CONTROL MOMENT GYROSCOPES [UPRAVLENIE UPRUGIMI KOLEBANIAMI AVIATIONNYKH KONSTRUKTSII PRI POMOSHCHI SILOVYKH GIROSKOPOV]**

R. I. VINOGRADOV, O. I. GAINUTDINOV, I. V. PETROV, and I. I. PETROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela (ISSN 0572-3299), July-Aug. 1986, p. 41-43. In Russian. refs

The possibility of using control moment gyroscopes for the damping of the elastic vibrations of the structural elements of the airframe is examined with reference to the basic schemes of gyroscopic damping systems, mathematical and physical models of aircraft equipped with such systems, and methods for selecting system parameters. The gyroscope stabilization systems discussed are systems based on the rate gyroscope and those based on the spring gyro pendulum. The problem of improving the flutter characteristics of the IL-86 aircraft is examined. V.L.

**A87-17752\*#** Systems Technology, Inc., Hawthorne, Calif.

## **A PERSPECTIVE ON SUPERAUGMENTED FLIGHT CONTROL - ADVANTAGES AND PROBLEMS**

D. MCRUER, D. JOHNSTON, and T. MYERS (Systems Technology, Inc., Hawthorne, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 530-540. refs (Contract NAS2-11388)

Superaugmented aircraft are an important subclass of actively controlled, highly augmented aircraft. The aircraft without augmentation is unstable; the control system not only redresses the stability and control imbalance, but also provides effective vehicle dynamics that differ in kind from those associated with conventional aircraft. In this paper, the longitudinal properties of highly unstable aircraft and typical superaugmented control systems used to remedy their dynamic deficiencies are explored generically. The topics considered include: (1) Basic flight control system architectures suitable to reduce or completely alleviate the unstable aircraft characteristics. (2) The primary dynamic characteristics and regulatory properties of typical superaugmented aircraft control systems, including governing factors in the linear system, dominant mode characteristics, and fundamental stability margin properties. The total available gain range factor is presented as a basic measure that relates degree of instability, control system limitations, and key control system adjustments. (3) Some flying qualities features for superaugmented aircraft with rate command/attitude hold, extended bandwidth, and attitude command configurations. Author

**A87-17753#**

## **FLYING QUALITIES OF PITCH RANGE COMMAND/ATTITUDE HOLD CONTROL SYSTEMS FOR LANDING**

C. R. CHALK (Calspan Corp., Buffalo, NY) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 541-545. refs

Experience with in-flight simulations has shown that pitch rate command/attitude hold flight control systems exhibit mediocre to poor flying qualities for landing. Pilots report poor control of the flight path and tendencies to balloon and float and to exhibit pilot-induced oscillations. The origin of this flight control concept is traced to analytical models of the pilot/vehicle dynamic system, to such pilot-in-loop design criteria as the crossover model 'law' of manual control, and to sensor redundancy considerations that discourage the use of air data and encourage the use of inertial sensors in flight control systems. Rate command systems reduce the bandwidth of the angle of attack and flight path rate control, alter the control feel for maneuvers, and force pilots to use a

pulse control technique and to push to land. For conventional airplane dynamics, the phugoid mode has low residue in the angle of attack and high residue in the pitch attitude and, in this situation, pitch attitude provides the pilot with surrogate cues for control of the angle of attack, flight path angle, and airspeed. Through pole-zero cancellation, the attitude response of a rate command system is made independent of the low-frequency modes of the characteristic equation and these dynamic modes, which must be controlled by the pilot in landing, are rendered unobservable in the pitch response of the rate command system. Author

**A87-17754#**

## **CONTROL LAW SYNTHESIS FOR AN AIRPLANE WITH RELAXED STATIC STABILITY**

J. D. BLIGHT, D. GANGSAAS, and T. M. RICHARDSON (Boeing Military Airplane Co., Seattle, WA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 546-554. refs

The synthesis of a command and stability augmentation control law for a transport airplane is presented. To improve fuel efficiency, the airplane has a relatively small horizontal tail surface and therefore has unsatisfactory inherent longitudinal stability. Over a wide range of center-of-gravity locations and the full flight envelope, the control law furnishes (1) task tailored column force gradients; (2) excellent dynamic responses for normal acceleration, pitch rate, and speed; and (3) better than  $\zeta = 0.5$  damping for the phugoid and short period modes. The control law is based on linear quadratic Gaussian synthesis at a single operating point. The gains are scheduled as functions of dynamic pressure and airplane flap position. The control is the elevator command and the sensors are column force, normal acceleration, pitch rate, airspeed, longitudinal acceleration, and vertical speed. Author

**A87-17755\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

## **FLIGHT EVALUATION OF AUGMENTED CONTROLS FOR APPROACH AND LANDING OF POWERED-LIFT AIRCRAFT**

J. A. FRANKLIN, C. S. HYNES, G. H. HARDY, J. L. MARTIN, and R. C. INNIS (NASA, Ames Research Center, Moffett Field, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 555-565. refs (AIAA PAPER 85-1944)

Flight experiments were conducted with Ames Research Center's Quiet Short-Haul Research Aircraft to evaluate the influence of highly augmented control modes on the ability of pilots to execute precision instrument flight operations in the terminal area, particularly approaches to and landings on a short runway. The aircraft is a powered-lift, short-takeoff and landing configuration that is equipped with a modern digital fly-by-wire flight control system, a head-up display, and a solar head-down display that make it possible to investigate control concepts and display format and content for full envelope, powered-lift operations. Considerable attention has been devoted in this flight program to assessing flightpath and airspeed command and stabilization modes developed using nonlinear, inverse model-following methods. The primary benefit of this control concept was realized when the pilot was required to execute a complex transition and approach under instrument conditions and in the presence of a wide range of wind and turbulence conditions. Author

**A87-17757\*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

## **IN-FLIGHT EVALUATION OF INCREMENTAL TIME DELAYS IN PITCH AND ROLL**

D. T. BERRY (NASA, Flight Research Center, Edwards, CA) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 39-46) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 573-577. Previously cited in issue 22, p. 3229, Accession no. A85-45881. refs

**A87-17758\*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**EFFECT OF TIME DELAY ON FLYING QUALITIES - AN UPDATE**

R. E. SMITH and S. K. SARRAFIAN (NASA, Flight Research Center, Edwards, CA) (Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers, p. 711-720) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 578-584. Previously cited in issue 23, p. 3409, Accession no. A86-47482. refs

**A87-17812#**

**LANDING APPROACH HANDLING QUALITIES OF TRANSPORT AIRCRAFT WITH RELAXED STATIC STABILITY**

K. WILHELM and D. SCHAFRANEK (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 449-458) Journal of Aircraft (ISSN 0021-8669), vol. 23, Oct. 1986, p. 756-762. Previously cited in issue 22, p. 3195, Accession no. A84-44978. refs

**A87-17904#**

**DESIGN ANALYSIS AND METHODOLOGY FOR EVALUATING FLIGHT CONTROL SYSTEMS**

S. L. GRAHAM (LTV Aerospace and Defense Co., Dallas, TX) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 16 p. refs (AIAA PAPER 86-2655)

Aircraft design methodologies and evaluation criteria are reviewed with attention given to linear analysis and nonlinear simulation. It is noted that the entire design process revolves about the basic stability criteria of the specific system being analyzed. These criteria can be divided into the following: airframe alone and the combination of the airframe/flight control system. K.K.

**A87-17939#**

**DESIGN AND DEVELOPMENT OF A THREE-AXIS AUGMENTATION SYSTEM FOR A CLASS III STOL ASSAULT TRANSPORT**

F. B. GREEN and S. K. HOFFMANN (Lockheed-Georgia Co., Marietta) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 12 p. refs (AIAA PAPER 86-2709)

Airframe configuration modifications were made to the High Technology Test Bed (HTTB) aircraft to provide acceptable short takeoff and landing (STOL) performance. A three-axis stability and command augmentation system was designed for the HTTB and resulted in excellent flying qualities for the augmented aircraft. This paper outlines the design and development of the pitch stability and command augmentation system (PSCAS) and the lateral/directional stability and command augmentation system (LDSCAS). It reviews the problems associated with this type of aircraft, discusses the design options that were available, and discusses the design and development of the augmentation control laws. Finally, the results of the design and development are presented by analyzing data from actual piloted evaluation on a motion base simulator. Author

**A87-17940#**

**REDUCING THE GAP BETWEEN THE QUANTITATIVE AND QUALITATIVE DESIGN, DEVELOPMENT AND TESTING OF CONTROL SYSTEMS**

B. L. HILDRETH (Systems Control Technology, Inc., Lexington Park, MD), R. A. BURTON (U.S. Navy, Simulation and Control Technology Dept., Patuxent River, MD), and U. H. RABIN (Systems Control Technology, Inc., Palo Alto, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. (AIAA PAPER 86-2710)

A linear model extraction method, which combines the control system's theoretical design and/or analysis to the piloted simulation, is described. The implementation of the control laws

on the piloted simulation is designed so that a linear model of the dynamic system can be extracted automatically at any flight simulator condition. The linear model is applied to a high performance aircraft with a high-order control system, and the extracted model response is compared with the full nonlinear simulation response. Good correlation between the linear and nonlinear data is observed. I.F.

**A87-17941#**

**FORMULATING AN INTEGRATED FLIGHT CONTROL LAW SYNTHESIS STRATEGY**

D. K. SCHMIDT (Purdue University, West Lafayette, IN) and M. R. ANDERSON AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 12 p. Research supported by the McDonnell Aircraft Co. refs (Contract F49620-85-C-0013)

(AIAA PAPER 86-2711)

Three different model-following techniques, all based on linear, quadratic optimization theory, are reviewed in light of their ability to address several of the most important flight control design objectives. The relevant design objectives include flying qualities specifications and stability robustness; with particular attention paid to the demands made on the actuation hardware by the resulting control system. Evaluation of the algorithms is based on theoretical considerations as well as numerical results pertaining to a preliminary control system study for a highly unstable fighter configuration. Author

**A87-17942\*#** Systems Technology, Inc., Hawthorne, Calif.

**CONNECTIONS BETWEEN CONVENTIONAL AND SINGULAR-VALUE-BASED MULTI-VARIABLE FLIGHT CONTROL SYSTEM DESIGN TECHNIQUES**

D. T. MCRUER, T. T. MYERS (Systems Technology, Inc., Hawthorne, CA), and P. M. THOMPSON (California Institute of Technology, Pasadena) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 13 p. refs

(Contract NAS1-17987)

(AIAA PAPER 86-2712)

It is proposed that frequency-domain multivariable robustness techniques, when combined with classical multivariable procedures, can offer an additional means of evaluating FCS designs. A lateral-directional FCS for an advanced fighter is used as an example. Robustness to unstructured aircraft-input uncertainties is assessed using purely numerical singular-value procedures. Literal approximations for the singular values of the open-loop plant and controller and for the inverse return difference are shown to provide a means of decomposing and diagnosing robustness problems that are insoluble via purely numerical methods. K.K.

**A87-18449**

**A320 - THE CHALLENGE OF FLY-BY-WIRE CONTROLS**

M. BOSSARD and B. KELLER Revue Aerospaciale (ISSN 0065-3780), Sept. 1986, p. 22-25. In English and French.

The A320 transport aircraft will have mechanical backup systems only for rudder control and emergency elevator control. The remainder of the control surfaces systems will be digitally controlled, i.e., for roll and pitch using the sidestick controllers. The selection of electronic controls has saved an estimated 300 kg in weight, and frees the pilot from any need to control the small responses of the aircraft to turbulence. Subroutines will prohibit the pilot from performing maneuvers which exceed the flight envelope of the A320, even in emergency situations. Various steps being taken to accelerate the debugging of the fly-by-wire control system so that it reaches operational status in time to permit the aircraft to be certified for flight in 1988 are described. M.S.K.

A87-18528#

**DETERMINATION OF OPTIMAL POSITION OF ACTUATORS FOR FLEXIBLE FLIGHT VEHICLES**

J. YUAN and S. CHEN (Northwestern Polytechnical University, Xian, People's Republic of China) *Acta Aeronautica et Astronautica Sinica*, vol. 7, Aug. 1986, p. 340-346. In Chinese, with abstract in English.

Since the action of actuators on flexible flight vehicles is an important exciting source to elastic vibration, it is of practical significance to choose appropriate positions for actuators as well as for sensors. The paper presents a study of optimal positions of rate gyros and elevators that are modelled as lumped operating elements. Through analysis, a set of simple and practical formulas that give the very positions at which the effective damping force is always dissipating is derived. It is shown that the present position of the elevator is suboptimal and is 0.06 m away from the optimal position.

Author

A87-18529#

**NUMERICAL SIMULATION OF A FLEXIBLE AIRCRAFT TAKING-OFF AND LANDING ON UNEVEN RUNWAY**

Y. RUI (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) *Acta Aeronautica et Astronautica Sinica*, vol. 7, Aug. 1986, p. 347-353. In Chinese, with abstract in English. refs

The use of Kane's (1961) equation to develop the dynamic equations of a flexible aircraft system including landing gear mechanisms is investigated in this paper. Two kinds of mathematical models of runway surface are given. The numerical simulation method is discussed for simulating the attitude, velocities, accelerations and dynamic loads of a flexible aircraft during take-off and landing, taking into account the effect of inertial forces and moments of large landing gear parts on the motion of the system. The symmetric take-off and landing of a KC-135 aircraft is simulated.

Author

A87-18536#

**PRELIMINARY STUDY OF MULTI-MODE CONTROL LAWS DESIGN METHODS FOR FIGHTER'S LONGITUDINAL CONTROL**

J. B. LU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) *Acta Aeronautica et Astronautica Sinica*, vol. 7, Aug. 1986, p. 405-411. In Chinese, with abstract in English.

This paper discusses methods for optimal control system design for a fighter. The pre-closed-loop and open-loop methods are studied according to control law structures and functions which are required by different flight conditions and tasks. Some numeric examples are provided. The performance index with the degree of stability  $\alpha$  is used and precise steady decoupling is obtained.

Author

A87-19239

**INTEGRATED SYSTEM IDENTIFICATION METHODOLOGY FOR HELICOPTER FLIGHT DYNAMICS**

G. D. PADFIELD (Royal Aircraft Establishment, Flight Research Div., Bedford, England) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 441-455. refs

The need for an integrated helicopter system identification methodology including state, model structure, and parameter estimation to reduce the levels of measurement noise and isolate important degrees of freedom is emphasized. The required processes in a systematic methodology are described. Stability variations with flight path angle for a Puma helicopter reveal how reduced-order models can occasionally offer an adequate description of vehicle dynamics.

K.K.

A87-19241\* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**SYSTEM IDENTIFICATION TECHNIQUES FOR HELICOPTER HIGHER HARMONIC CONTROL**

S. A. JACKLIN (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 465-481. refs

This paper presents and compares several system identification techniques proposed for use with higher harmonic control algorithms designed to alleviate helicopter vibration. All method for actively controlling helicopter vibration require the knowledge of how the vibration outputs are related to the control inputs. Off-line or batch identification methods for obtaining this knowledge are presented first. Then the more advanced, adaptive identification techniques proposed to track the helicopter model parameters in flight are discussed. Considerations regarding system identifiability, identification algorithm stability, and computer implementation are also discussed.

Author

A87-19254

**V-22 CONTROL LAW DEVELOPMENT**

K. W. GOLDSTEIN (Boeing Vertol Co., Ridley Park, PA) and L. W. DOOLEY (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 673-684. refs

The V-22 Osprey tilt rotor control law development that has been conducted during the 30 month preliminary design is described. The control law development has emphasized the flexibility of the tilt rotor configuration while minimizing flying qualities deficiencies with innovative use of the fly-by-wire control system. Separated Primary and Automatic Flight Control Systems (PFCS and AFCS), control input lead shaping, and command response tailoring are three of the prime features of the V-22 control laws. The V-22 type specification requires that mission completion be demonstrated (a minimum of Level 2 handling qualities) for both AFCS ON and AFCS OFF flight configurations. Piloted simulation results for a variety of flight tasks have shown Level 1 to borderline Level 1/Level 2 ratings with the AFCS ON, and Level 2 ratings with the AFCS OFF.

Author

A87-19256

**ADVANCED FLIGHT CONTROL DEVELOPMENT FOR SINGLE-PILOT ATTACK HELICOPTERS**

R. HENDRICK, G. RAMOHALLI, D. YANKE (Honeywell, Inc., Minneapolis, MN), R. FORTENBAUGH, and T. FREEMAN (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 711-725.

The design and performance of highly augmented manual and automatic flight control modes for helicopters with high pilot workloads are described. The control implementation, tested in a Model 249 (four-bladed) Bell YAH-1S cobra, centers on two self-checking microprocessor pairs, coupled with laser inertial reference units (IRUs) and full-authority actuation. The manual mode provides full-envelope control with desirable handling qualities, and enables periods of hands-off operation. The function in pitch and roll is rate command with speed-dependent acceleration or attitude hold. Yaw control is rate command/heading hold at low speed, with turn coordination at high speed. Manual heave control augments collective stick with normal velocity. The automatic mode provides four-axis hover position hold with velocity command capability, resulting in a stable yet agile weapons platform for pop-up and remask operations.

Author

A87-19257

**HANDLING QUALITIES EVALUATION OF THE ADOCS PRIMARY FLIGHT CONTROL SYSTEM**

S. I. GLUSMAN, K. H. LANDIS, and C. DABUNDO (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 727-737. refs

(Contract DAAK51-82-C-0002)

As a part of the Army's Advanced Digital Optical Control System (ADOCS) program, a handling qualities flight evaluation of advanced flight control law concepts was conducted on a modified UH-60A helicopter. Results from piloted flight evaluations were compared to results from previously conducted simulations performed while developing the ADOCS side-stick controllers and control laws for unaugmented flight. Flight evaluations conducted using the production UH-60 mechanical controls were also conducted. Comparison of data shows that unaugmented handling qualities of the UH-60 flown with either the production system or with the DOCS (with separated controllers) are Level-2 for all tasks performed. I.S.

A87-19266\* Stanford Univ., Calif.

**NEW CAPABILITIES AND RECENT RESEARCH PROGRAMS OF THE NASA/ARMY CH-47B VARIABLE-STABILITY HELICOPTER**  
W. S. HINDSON (Stanford University, CA), K. B. HILBERT, G. E. TUCKER, R. T. N. CHEN, and E. B. FRY (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 845-863. refs

The CH-47B is the third in a series of variable-stability helicopters developed and operated by NASA since 1952 to investigate helicopter and VTOL handling qualities. Recently, several new capabilities were added to this helicopter to enable it to better support new and evolving research requirements. The installation of a programmable force-feel system for the evaluation pilot's conventional cyclic stick, and a four-axis side-stick controller permit a range of in-flight investigations concerning manipulator characteristics and augmentation system features that had not been possible with earlier NASA research helicopters. A recently installed color electronic display system with a programmable symbol generator will permit the investigation of display formats for a variety of VTOL and helicopter missions. Finally, a powerful new general-purpose flight computer is now in operation. It is programmable in high-level languages and will provide more efficient support of research programs. In addition to these new hardware capabilities, flight-control software has been developed to improve the in-flight simulation capability of the aircraft. A brief description of the CH-47B's variable-stability research equipment is provided, recent research programs are summarized, and some remarks concerning the potential of the helicopter are presented.

Author

**N87-13445#** Royal Aircraft Establishment, Farnborough (England).

**HELICOPTER FLIGHT CONTROL RESEARCH: A DEMANDING APPLICATION OF PILOTED SIMULATION**

S. L. BUCKINGHAM Jan. 1986 40 p Presented at the Royal Aeronautical Society International Conference on Flight Simulation of Helicopters - Status and Prospects, London, England, Apr. 1985

(RAE-TM-FS(B)-595; BR99585; ETN-86-98376; AD-A169550)

Avail: NTIS HC A03/MF A01

Piloted simulation research in helicopter handling qualities is reviewed. Studies addressed the application of advanced control systems to enhance agility in Nap-of-the-Earth (NOE) flight. Handling qualities research places particular demands on many components of the simulator, including software environment and computing, cockpit design, and simulator operation. The requirements in terms of provision of adequate visual and motion

cues are especially severe for agile NOE flight. An advanced flight simulator is described. ESA

**N87-13446\*#** Boeing Commercial Airplane Co., Seattle, Wash.  
**AUTOMATIC BRAKING SYSTEM MODIFICATION FOR THE ADVANCED TRANSPORT OPERATING SYSTEMS (ATOPS) TRANSPORTATION SYSTEMS RESEARCH VEHICLE (TSRV)**

**Final Report**

J. J. COOGAN Oct. 1986 74 p

(Contract NAS1-17635)

(NASA-CR-178155; NAS 1.26:178155; D6-38012) Avail: NTIS

HC A04/MF A01 CSCL 01C

Modifications were designed for the B-737-100 Research Aircraft autobrake system hardware of the Advanced Transport Operating Systems (ATOPS) Program at Langley Research Center. These modifications will allow the on-board flight control computer to control the aircraft deceleration after landing to a continuously variable level for the purpose of executing automatic high speed turn-offs from the runway. A bread board version of the proposed modifications was built and tested in simulated stopping conditions. Test results, for various aircraft weights, turnoff speed, winds, and runway conditions show that the turnoff speeds are achieved generally with errors less than 1 ft/sec. Author

**N87-14274#** National Aerospace Lab., Tokyo (Japan).

**INVESTIGATION OF A PREDICTION METHOD OF TRANSONIC FLUTTER CHARACTERISTICS USING UNSTEADY TRANSONIC AERODYNAMICS**

H. ARAKAWA, H. NOMOTO, N. TODA, and K. HIRAOKA In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 243-249 Nov. 1985 In JAPNAESE; ENGLISH summary

Avail: NTIS HC A12/MF A01

Theoretical studies to predict aircraft transonic flutter phenomena are reviewed and a practical method based on nonlinear transonic aerodynamic is proposed for estimating flutter characteristics of aircraft in their initial design phase. This analytical tool consists of two and three dimensional subsonic aerodynamic calculations corrected by two dimensional transonic aerodynamic computations to account for the shock movement on the wing surface. The present analytical procedure is fairly good at predicting the flutter characteristics of the wing wind tunnel flutter test model of the YXX, the next commercial transport currently under study. This result indicates the wide applicability of the method to the flutter estimation of aircraft with high aspect ratio wings. Author

**N87-14352#** European Space Agency, Paris (France).

**A CONTRIBUTION TO DIGITAL COMPENSATION OF PERIODIC DISTURBANCES WITH FREQUENCIES IN BOUNDED INTERVALS**

R. FRORIEP Sep. 1986 140 p Original language document was announced as N86-21553

(ESA-TT-979; DFVLR-FB-85-55; ETN-87-98886) Avail: NTIS HC A07/MF A01; original German version available from DFVLR, Cologne, West Germany DM 45.40

A general design method for the simplest possible compensator was developed in order to satisfy the requirement of stationary disturbance compensation within given tolerance limits for all helicopter rotor speeds within a given bounded interval. The approach to the suppression of rotor induced vibrations is to suspend the fuselage from the rotor by electrohydraulic actuators. Using a digital computer the most dominant harmonics of the disturbance can be actively compensated. For compensation at sampling instants, a structure of a digital controller is introduced and motivated, in which a minimal number of parameters is adapted to a varying rotor speed. The remaining parameters are to be held constant during operation independent of rotor speed. In the design, these parameters are systematically improved with a multi-disturbance model-approach and a design methodology with vector performance index. For disturbance suppression between sampling instants a design method for impulse forming filters is proposed. ESA

**N87-14353** Texas Univ., Arlington.

## **THE HANDLING QUALITIES OF A LARGE JET TRANSPORT AIRCRAFT IN SEVERE WIND SHEAR AND TURBULENCE Ph.D. Thesis**

B. R. MULLINS, JR. 1985 216 p  
 Avail: Univ. Microfilms Order No. DA8611264

The effects of a variable wind field and heavy rain on the flying qualities of a large wide-body multiengine jet transport were examined by developing a six degree-of-freedom rigid-body simulation with a yaw damper control system. The simulation included nonlinear aerodynamics with aeroelastic, Mach, and load factor elements. The aircraft model was verified by comparison to previous simulations and flight tests. Linear analysis was performed by using small perturbation theory. The linearized aerodynamic coefficients were determined by small motion analysis of the full model about a trimmed flight condition. By running time histories of atmospheric wave and gust responses, the linear analysis was verified from small motions. Dissert. Abstr.

# 09

## **RESEARCH AND SUPPORT FACILITIES (AIR)**

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

**A87-16762\*** Lockheed-Georgia Co., Marietta.

## **A NEW MEANING TO 'FLYING THE DESK'**

G. A. SEXTON (Lockheed-Georgia Co., Marietta, GA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 360-366.

(Contract NAS1-16199)

A unique advanced transport flight station design is described. The various systems and displays of the design are described, including: the configuration; switches; tailored logic/artificial intelligence; primary flight controllers; front panel displays; primary flight/navigation display; engine power/status, approach charts, and weather display; the Advisory, Caution, and Warning System/Cockpit Display of Traffic Information display; checklist/functional systems display; head-up display; voice command and response system; Flight Management Computer system; and integrated communications/navigation system. The application of the flight station to military research is briefly discussed. C.D.

**A87-16777**

## **DEVELOPMENT AND APPLICATION OF IN-FLIGHT SIMULATOR AIRCRAFT FOR FLYING QUALITIES RESEARCH AT DFVLR**

D. HANKE, K. WILHELM, and H.-L. MEYER (DFVLR, Brunswick, West Germany) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 490-498. refs

In-flight simulation as a general research technique has been applied by DFVLR since the early 1970's using the HFB 320 aircraft. This in-flight simulator was successfully used in various handling quality flight experiments until 1984. Based on the experiences gained with the HFB 320, a new advanced in-flight simulator ATTAS (Advanced Technologies Testing Aircraft System) based on VFW 614 aircraft has been developed recently by DFVLR which will be operational in 1986. The in-flight simulation concept of ATTAS encloses a full authority dual-redundant digital fly-by-wire/light system based on nine fiber optic-linked computers. Direct lift modulation capability has been added by using fast moving trailing edge flaps. Author

**A87-16827**

## **IESS - DYNAMIC TEST AND EVALUATION FACILITY FOR INTEGRATED CNI**

D. G. HALDEMAN (TRW, Inc., TRW Defense Systems Group, Redondo Beach, CA) and E. WALLACE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1001-1005. refs

Features and applications of an integrated electromagnetic systems simulator (IESS) being developed to provide generic communications, navigation and identification (CNI) systems test capabilities for the Air Force are described. The IESS will generate, receive and respond with RF signals in the 2 MHz-1 GHz range in real-time for CNI units under test (UUT). Signals from satellites, stand-off jammers, ground stations, and other aircraft will be available for stimulating the dynamic environment of the UUTs. Account will be taken of the data rates and the flight paths of other signal-generating aircraft. The IESS is modular, which permits alterations to generate and receive new waveforms as they are identified. M.S.K.

**A87-17922#**

## **THE AIR COMBAT SIMULATOR AND ITS ROLE IN THE AIRCRAFT DEVELOPMENT PROCESS**

D. M. BALDWIN and J. D. DREWETT (General Dynamics Flight Simulation Laboratory, Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 9 p.  
 (AIAA PAPER 86-2682)

Attention is given to the dual-dome Air Combat Simulator (ACS) which is designed to provide an air combat environment for use during the conceptual and design phases of an airplane development program. Through the addition of a 'hardware-in-the-loop' capability, a system can be provided that is equally useful during final developmental phases. It is concluded that the use of simulators such as the ACS is critical because of the conflicts which are currently arising between the trends of modern fighter aircraft and sensor development. K.K.

**A87-19217**

## **DESIGN OF MCDONNELL DOUGLAS HELICOPTER COMPANY'S NEW COMPOSITE DEVELOPMENT CENTER**

K. L. OBRACHTA (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 183-187.

**A87-19252\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

## **PILOT USE OF SIMULATOR CUES FOR AUTOROTATION LANDINGS**

W. A. DECKER, C. F. ADAM, and R. M. GERDES (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 635-655. refs

A ground-based simulator experiment was conducted to investigate the influence of simulator cue variations on helicopter autorotation landing-task performance. Using the NASA Ames Research Center Vertical Motion Simulator (VMS), variations were made in motion-system performance and selection of either longitudinal or lateral linear acceleration cues. Analysis of landing performance statistics and pilot commentary revealed that task performance changed with degraded motion cues. However, fixed base (no motion) could provide acceptable landing performance if adequate visual cues were present. Longitudinal linear-acceleration cues assisted one pilot's control of the landing forward speed, while lateral linear-acceleration cues assisted in control of lateral drift or sideslip. Variations were also made in the content and details of visual landing scenes. Pilot commentary collected on the use of three landing scenes stressed the importance of



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receiving consistent, easily recognized, position, attitude, and speed cues from the visual scene. The importance of subtle aural cues to pilot acceptance of the simulation was also noted. Author

**A87-19253**

**AN INVESTIGATION OF SINGLE-PILOTED ADVANCED COCKPIT AND CONTROL CONFIGURATIONS FOR NAP-OF-THE-EARTH HELICOPTER COMBAT MISSION TASKS**  
L. A. HAWORTH, C. C. BIVENS, and R. J. SHIVELY (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 657-672. refs

**A87-19279\*** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
**CONTROL AND DISPLAY REQUIREMENTS FOR DECELERATING APPROACH AND LANDING OF FIXED- AND ROTARY-WING VSTOL AIRCRAFT**

J. V. LEBACQZ, V. K. MERRICK, and J. A. FRANKLIN (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 1025-1045. refs

This paper reviews the results of several simulation investigations of rotary-wing and fixed-wing VSTOL aircraft performing terminal-area operations that include decelerating approaches under instrument conditions and recovery to either fixed landing pads or a ship. By concentrating on instrument decelerating approaches and the hover and landing, it is possible to compare directly the control and display requirements for similar tasks for aircraft with and without vectored thrust capability. Collectively, the results from these experiments, together with other simulator and flight experiments and operational experience, provide a consistent view of control and display complexity required for similar operational capability in adverse weather for the two types of VSTOL configurations. Some initial data showing influence of the transition corridor on flying qualities during transition are presented and lead to a general discussion of the problem of operating margin definition. Author

**N87-13450\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**WIND TUNNEL WALL INTERFERENCE IN V/STOL AND HIGH LIFT TESTING: A SELECTED, ANNOTATED BIBLIOGRAPHY**  
M. H. TUTTLE (Vigyan Research Associates, Inc., Hampton, Va.), R. E. MINECK, and K. L. COLE Dec. 1986 52 p  
(NASA-TM-89066; L-16257; NAS 1.15:89066) Avail: NTIS HC A04/MF A01 CSCL 14B

This bibliography, with abstracts, consists of 260 citations of interest to persons involved in correcting aerodynamic data, from high lift or V/STOL type configurations, for the interference arising from the wind tunnel test section walls. It provides references which may be useful in correcting high lift data from wind tunnel to free air conditions. References are included which deal with the simulation of ground effect, since it could be viewed as having interference from three tunnel walls. The references could be used to design tests from the standpoint of model size and ground effect simulation, or to determine the available testing envelope with consideration of the problem of flow breakdown. The arrangement of the citations is chronological by date of publication in the case of reports or books, and by date of presentation in the case of papers. Included are some documents of historical interest in the development of high lift testing techniques and wall interference correction methods. Subject, corporate source, and author indices, by citation numbers, have been provided to assist the users. The appendix includes citations of some books and documents which may not deal directly with high lift or V/STOL wall interference, but include additional information which may be helpful. Author

**N87-13453#** Air Force Human Resources Lab., Brooks AFB, Tex.

**FLIGHT SIMULATOR: FIELD OF VIEW UTILIZED IN PERFORMING TACTICAL MANEUVERS** Final Report, Jan. 1983 - Dec. 1984

L. A. WIEKHORST and F. T. VACCARO Sep. 1986 30 p  
(AD-A172048; AFHRL-TP-86-29) Avail: NTIS HC A03/MF A01 CSCL 051

This paper documents the field of view (FOV) utilized by experienced fighter pilots when performing specified portions of air-to-air and air-to-ground maneuvers. The FOV measurements were taken in the Simulator for Air-to-Air Combat (SAAC) and the Advanced Simulator for Pilot Training (ASPT). Results indicate that the FOV utilized varied widely between air-to-air and air-to-ground maneuvers. In nearly all cases, the FOV utilized for air-to-air maneuvers was symmetrical and that for air-to-ground maneuvers was skewed to one side. When air-to-ground tasks were performed in an LFOV, no significant in bomb scores was found when compared to wide-FOV performance. A noticeable performance change in the LFOV condition was a tendency of the pilots to turn tighter into the target. The true effect of this change in flight path still needs to be investigated. Specifying one optimal LFOV for all maneuvers to be performed or trained in an operational flight simulator would be difficult if both cost and performance were to be considered. This investigation, along with previous research, gives evidence that simulators with LFOV visual systems can be used to perform many tasks, including basic flight, takeoffs, landings, and straight-in tactical weapons delivery, especially by experienced pilots. The variability of the FOV leads to the conclusion that placement of LFOV will be an important decision when considering what tasks will be performed. GRA

**N87-13454#** Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.  
**PERFORMANCE PREDICTION OF LOW VOLUME AIRFIELD PAVEMENTS** Final Report, 1984 - 1985

A. J. BUSH, III Sep. 1986 201 p  
(AD-A172270; WES-TR-GL-86-14) Avail: NTIS HC A10/MF A01 CSCL 13B

A pavement evaluation procedure is presented for evaluating conventional flexible airfield pavements that will fail in fewer than 100 coverages. The procedure utilizes deflection data obtained from a Falling Weight Deflectometer and the age of the pavement to predict the coverages of an F-4 aircraft to failure. Procedures for correcting temperature of the asphalt pavement layer and for predicting performance of other aircraft are presented. GRA

**N87-13455#** Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics.  
**WIND TUNNELS AND TEST RIGS OF THE DEPARTMENT OF AERONAUTICS, IMPERIAL COLLEGE**

P. BRADSHAW Apr. 1986 6 p Supersedes IC-Aero-79-05  
(IC-AERO-86-02; IC-AERO-79-05; ISSN-0308-7247; ETN-86-98391) Avail: NTIS HC A02/MF A01

Dimensions and details for 17 test rigs, ranging from a water channel to a Mach 25 nitrogen tunnel are given. These are the main facilities used for teaching and research. Details of minor or temporary rigs are not included. ESA

**N87-14354** Flughafen, Frankfurt am Main (West Germany).  
**THE SIMULATOR: THE PERFECT ILLUSION [DER SIMULATOR - DIE PERFEKTE ILLUSION]**

H. AUTH Mar. 1986 19 p In GERMAN  
(FACHTHEMEN-9; ETN-87-98862) Avail: Issuing Activity

The development of flight simulator systems and pilot training is reviewed. Critical operations like emergency descent and roll can be practiced on the ground without danger. Plans for an entire pilot training on flight simulators are discussed. ESA



## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

**N87-14356#** New Mexico Univ., Albuquerque. Engineering Research Inst.  
**ASPHALT-RUBBER SAMI (STRESS-ABSORBING MEMBRANE INTERLAYERS) FIELD EVALUATION Final Report, 29 Oct. 1984 - 30 Sep. 1985**

R. G. MCKEEN, R. D. PAVLOVICH, and V. CASSINO Apr. 1986 161 p

(Contract F29601-84-C-0080)

(AD-A169700; NMRI-WA5-7(5.06); AFESC/ESL-TR-86-02)

Avail: NTIS HC A08/MF A01 CSCL 13C

The investigation of asphalt-rubber mixtures for use as stress-absorbing membrane interlayers (SAMIs) for airfield pavements is described. The project was initiated in 1977 as a state-of-the-art review, which study concluded that use of SAMIs was promising for improving the performance of asphalt-concrete overlays on airfield pavements. A following study addressed material characterization and development of a proposed construction specification. This report covers follow-on monitoring of the performance of an experimental pavement project at Kirtland AFB, Apron A; construction and performance monitoring of two trial sections located at Williams AFB and Coolidge Field in Arizona; and the design and construction of a field experiment at Peterson AFB, Colorado. Based on the results obtained to date, the performance observed cannot be related in a meaningful way to the material characteristics. This results from the small time elapsed since construction of the pavements under observation. Based on experience, a revised proposed construction specification is included in the current report. Continued performance monitoring is recommended in order to obtain the benefit from the investment made initially.

GRA

**N87-14357#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.

**DEVELOPMENT OF MECHANISTIC FLEXIBLE PAVEMENT DESIGN CONCEPTS FOR THE HEAVYWEIGHT F-15 AIRCRAFT Ph.D. Thesis**

H. F. KELLY, IV 1986 232 p

(AD-A170902; AFIT/CI/NR-86-88D) Avail: NTIS HC A11/MF A01 CSCL 01E

A new configuration of the F-15 aircraft is being used by the U.S. Air Force. This heavyweight F-15 has a 30-kip/355-psi wheel loading. The F-15 will become the controlling aircraft for design of airfield Light-Load Pavements. A review is presented of the concepts and development of the present Department of Defense (DOD) method for flexible airfield pavement design. The structural model used in this study to calculate pavement structural responses (stresses, strains, deflections) is the finite element program ILLI-PAVE. This program considers the pavement as an axisymmetric solid, and accommodates stress-dependent materials and soils, and stress corrections according to Mohr-Coulomb failure criteria. Multiple regression analyses are performed on the ILLI-PAVE data base to develop prediction equations (algorithms) for pavement structural responses of interest. These equations have high statistical precision when compared against the ILLI-PAVE data base. Therefore, they may be used in lieu of running ILLI-PAVE, which generally requires a main-frame computer. Pavement test section data obtained from the literature are analyzed using ILLI-PAVE. Transfer functions are derived relating calculated pavement responses to coverages till failure.

GRA

## 10

### ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications; spacecraft communications; command and tracking; spacecraft design; testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A87-18138**

### INTEGRATED POWER AND ATTITUDE CONTROL SYSTEM (IPACS) TECHNOLOGY

R. E. OGLEVIE (Rockwell International Corp., Space Station Systems Div., Downey, CA) and D. B. EISENHAURE (SATCON Technology Corp., Cambridge, MA) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3. Washington, DC, American Chemical Society, 1986, p. 1834-1837. refs

Integrated power and attitude control system (IPACS) studies performed over a decade ago established the feasibility of storing electrical energy in flywheels and utilizing the resulting angular momentum for spacecraft attitude control. Such a system has been shown to have numerous attractive features relative to more contemporary technology, and is appropriate to many applications (including high-performance slewing actuators). Technology advances over the last two decades in composite rotors, motor/generator/electronics, and magnetic bearings are found to support the use of IPACS for increasingly sophisticated applications. It is concluded that the concept offers potential performance advantages as well as savings in mass and life-cycle cost.

Author

## 11

### CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

**A87-17182**

### REQUIREMENTS FOR ENGINEERING CERAMICS IN GAS TURBINE ENGINES

A. BENNETT (Rolls-Royce, Ltd., Derby, England) (Institute of Metals and Institute of Ceramics, Meeting on Ceramics in Engines, London, England, Nov. 19, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, Sept. 1986, p. 895-899. refs

The potential uses of ceramics in gas turbine engines are reviewed in the context of the problems arising from the brittle nature of the materials. Material properties are considered in relation to various turbine components and the themes of reliability and component design. It is concluded that substantial efforts will be required in materials and processes in achieving greater reliability and improved design before ceramics are successfully applied in gas turbines.

Author

**A87-17283**

### MATERIALS FOR AEROSPACE

M. A. STEINBERG (California, University, Los Angeles) Scientific American (ISSN 0036-8733), vol. 255, Oct. 1986, p. 67-72.

Advances in both materials and fabrication processes are noted to play a key role in prospective high-performance-aircraft and spacecraft development. An evaluation is presented for primary airframe structure composites and alloys, ceramic- and glass-matrix composites for propulsion systems, and carbon/carbon refractory

composites for elevated temperature applications. Major processing advances discussed encompass centrifugal and inert gas atomization of alloy powders, hot extrusion, and dynamic compaction. Attention is given to the unique materials called for in the structure of the projected NASA hypersonic/transatmospheric vehicle. O.C.

A87-17287

**ADVANCED METALS**

B. H. KEAR (Exxon Corporate Research Center, Annandale, NJ) Scientific American (ISSN 0036-8733), vol. 255, Oct. 1986, p. 159-167.

A development status report is presented for novel processing techniques that exploit metallic crystalline structure irregularities to yield heat- and corrosion-resistant alloys that could withstand the centrifugal and other mechanical loads of gas turbine engine components. Attention is given to processing methods for the Ni-Al, Ni, and Ti based alloys; the methods encompass rapid solidification of alloy particles for subsequent high pressure consolidation, directional solidification of cast alloys, oxide dispersion strengthening by means of mechanical alloying, and various coating and bonding techniques. O.C.

A87-17465

**THE EFFECT OF PROTECTIVE COATINGS ON THE HIGH-TEMPERATURE FATIGUE OF HEAT-RESISTANT ALLOYS [VLIANIE ZASHCHITNYKH POKRYTII NA VYSOKOTEMPRA-TURNUIU USTALOST' ZHAROPROCHNYKH SPLAVOV]**

IU. G. VEKSLER, V. V. GRIBOV, V. P. LESNIKOV, A. A. RABINOVICH, G. F. MIALNITSA (Ural'skii Politekhnikheskii Institut, Sverdlovsk, USSR) et al. Problemy Prochnosti (ISSN 0556-171X), Aug. 1986, p. 76-78. In Russian. refs

The fatigue properties of EP539LM alloy with an Al-Nb-Si fused slurry coating and a Co-Cr-Al-Y electron-beam coating are investigated experimentally in vacuum and in air at 900 C. It is found that the protective coatings reduce the fatigue life of the specimens both in vacuum and in air, with the electron-beam coating affecting the fatigue life of the alloy to a lesser degree than the fused slurry coating. The negative effect of the coatings on the fatigue life of the alloy is attributed largely to the properties of the coating material. V.L.

A87-17824

**IMPACT FRACTURE OF CHEMICALLY TEMPERED GLASS HELICOPTER WINDSHIELDS**

M. M. ABOU EL LEIL (United Technologies Research Center, East Hartford, CT), F. A. CAMARATTA, and R. R. DIGENOVA (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) American Ceramic Society, Journal (ISSN 0002-7820), vol. 69, Sept. 1986, p. 713-716. refs

Helicopter windshield glass with different degrees of chemical tempering was impact tested by firing spherical projectiles at velocities between 50 and 250 m/s. The residual tempering stresses were measured photoelastically and their values superimposed on the Hertzian impact stresses. Modified forms of Auerbach's law were utilized to study the experimental results. Lower impact fracture strength and deviations from the modified relations were attributed to changes in surface flaw distributions. Author

A87-17973#

**CHARACTERIZATION OF OPTICAL AND SURFACE PARAMETERS DURING PARTICLE IMPACT DAMAGE**

P. VEERABHADRA RAO (Tata Consulting Engineers, Bangalore, India) ASME, Transactions, Journal of Engineering Materials and Technology (ISSN 0094-4289), vol. 108, Oct. 1986, p. 296-302. refs

The damage caused by sand impingement can be severe and detrimental to canopies, radomes, wind screens, and structural components, resulting in loss of transmittance, communications, and premature failure. Extensive parametric studies were conducted to characterize the optical transmittance characteristics of

polymethyl methacrylate and polycarbonate surfaces as functions of velocity of impact, exposure time, distance of the nozzle, angle of impingement, and mass flow rate of the erodent. Particle damage was caused by a jet of high-speed spherical and (crushed glass and silicon carbide) angular particles. The relationship between the optical and surface characteristics is discussed. Author

A87-19123\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**FABRICATION AND QUALITY ASSURANCE PROCESSES FOR SUPERHYBRID COMPOSITE FAN BLADES**

R. F. LARK and C. C. CHAMIS (NASA, Lewis Research Center, Cleveland, OH) Journal of Composites Technology and Research (ISSN 0885-6804), vol. 8, Fall 1986, p. 98-102. Previously announced in STAR as N85-14882. refs

The feasibility of fabricating full-scale fan blades from superhybrid composites (SHC) for use large, commercial gas turbine engines was evaluated. The type of blade construction selected was a metal-spar/SHC-shell configuration, in which the outer shell was adhesively bonded to a short, internal, titanium spar. Various aspects of blade fabrication, inspection, and quality assurance procedures developed in the investigation are described. It is concluded that the SHC concept is feasible for the fabrication of prototype, full-scale, metal-spar/SHC-shell fan blades that have good structural properties and meet dimensional requirements. R.S.F.

A87-19373

**ADHESION IN BONDED ALUMINIUM JOINTS FOR AIRCRAFT CONSTRUCTION**

W. BROCKMANN, O.-D. HENNEMANN, H. KOLLEK (Fraunhofer-Institut fuer Angewandte Materialforschung, Bremen, West Germany), and C. MATZ (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) International Journal of Adhesion and Adhesives (ISSN 0143-7496), vol. 6, July 1986, p. 115-143. BMFT-supported research. refs

The formation and behavior of structural bonded Al joints are examined. The main components of an adhesive system, the Al adherend, the oxide layers produced by chemical pretreatment processes, the primers, and the adhesives, are analyzed. Consideration is given to the metal/oxide boundary layer, the primer/oxide boundary layer, and the primer/adhesive phase boundary. The effects of the adhesional system on the behavior of the joints in the boundary layer zone, and or moisture, water, and a corrosive environment on the durability of the adhesive joints are investigated. The alkaline failure and the acidic degradation mechanisms are described. Future research in the areas of adhesives and pretreatment processes is discussed. I.F.

N87-13496# Centre d'Essais de Propulseurs, Saclay (France). GLASFLUGEL H 201 LIBELLE GLIDER: AGING STUDY, TEST REPORT, PART 1 [PLANEURS H 201 LIBELLE FABRIQUES PAR LA SOCIETE GLASFLUEGEL. ETUDE DU VIEILLISSEMENT]

11 Feb. 1986 29 p In FRENCH Sponsored by Service Technique des Programmes Aeronautiques (REPT-3707-LC-85-PT-1; CEPR-594-PT-1; ETN-86-98434) Avail: NTIS HC A03/MF A01

Composite materials used in the wings of 2 gliders produced at a 13 yr interval were tested in order to verify the aging of the glass-epoxy composite. The tests included axial compression, flexion, flexion peeling, and tensile tests. The results show a mechanical degradation due to aging and independent of the flight history. This aging is not taken into account by the glider's manufacturer. ESA

## 11 CHEMISTRY AND MATERIALS

**N87-13545#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**AERODYNAMIC BREAKUP OF POLYMER SOLUTIONS VIA DIGITAL IMAGE PROCESSING TECHNIQUES Contractor Report, Nov. 1982 - Jun. 1985**

M. A. HERNAN, P. PARIKH, A. YAVROUIAN, and V. SAROHIA  
Apr. 1986 39 p  
(Contract MIPR-23111-1249)  
(AD-A170982; CRDEC-CR-86020) Avail: NTIS HC A03/MF A01  
CSCL 20D

The behavior of viscoelastic polymer solutions when exposed to high velocity airstream have been experimentally investigated. High speed pulsed laser photographic and digital image enhancement techniques have been used to visualize and characterize in-flight breakup of polymer solutions. Experiments with several polymer concentrations and various temperatures have been conducted in two facilities. The first set-up utilizes a high speed, free-jet flow and provides initial transient breakup behavior. Increased flight time for polymer relaxation was achieved by a unique co-flowing jet facility developed for this task. Limited data obtained on this set-up are also presented. GRA

**N87-13566\*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

**EVALUATION OF FM-9 ANTIMISTING KEROSENE VARIANTS Final Report, Jul. 1982 - Aug. 1983**

A. YAVROUIAN, P. PARIKH, L. BERNAL, and V. SAROHIA Sep. 1986 71 p  
(Contract NAS7-918; DTFA03-80-A-00215)  
(NASA-CR-180015; JPL-PUB-D-1599; NAS 1.26:180015;  
FAA-CT-85-3) Avail: NTIS HC A04/MF A01 CSCL 81H

Evaluation of FM-9 antimisting kerosene (AMK) variants developed by Imperial Chemical Industries (ICI) to improve the dissolution rate of mist suppression polymers in Jet A is discussed. Dissolution rate characteristics are important for the proposed AMK in-line blending associated with the aircraft fueling operation to minimize refueling turnaround time, enhance real-time quality control, and potentially simplify the blending equipment design requirements. The results obtained with these variants are compared with those obtained with batch blended FM-9 prepared by ICI. The key findings of this effort are: (1) The dissolution rate of FM-9 variants (most batches) is better than FM-9. (2) The feasibility of single pass in-line blending for all additives under investigation was demonstrated. (3) Powder particle size uniformity and slurry viscosity need optimization, otherwise the benefits of the faster dissolution rate cannot be realized. (4) Flow rate measured at 10 psi head pressure with AMK was approximately 40 percent lower than that of Jet A at ambient (20 C) and low temperature (-35 C). Freshly in-line blended AMK fuels pumped as well as equilibrated batch blended fuel. Author

**N87-14333#** Stuttgart Univ. (West Germany).

**ELEMENTARY-REACTION AND FLOW-MECHANICAL PROBLEMS IN AIRCRAFT AND SPACECRAFT DRIVES [ELEMENTAR-REAKTION UND STROEMUNGSMECHANISCHE PROBLEME DER LUFT- UND RAUMFAHRTANTRIEBE]**

H. H. GROTHEER and U. MEIER In *its* Thermodynamic and Flow Mechanical Problems in Aircraft and Spacecraft Drives p 25-56 Apr. 1986 In GERMAN  
Avail: NTIS HC A20/MF A01

The elementary reactions in the oxidation of methanol and ethanol were investigated to optimize combustion processes with respect to efficiency and pollutant emission. The use of flow reactors with mass spectrometry and laser induced fluorescence made it possible to clarify the complex reaction mechanisms, and to quantitatively measure the reaction speed constants of the elementary reactions which constitute these mechanisms. The accompanying numerical simulation of the global system was especially important. In the reaction system of the methanol oxidation all essential elementary reactions, except reactions with hydrogen atoms, were analyzed. For ethanol oxidation, the important reactions  $C_2H_5OH + O$  and  $C_2H_5OH + OH$  were analyzed. ESA

**N87-14437#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Strukturmechanik.

**PROCEEDINGS OF A STRUCTURAL MECHANICS COLLOQUIUM OF NONDESTRUCTIVE TESTING OF FIBER REINFORCED STRUCTURES**

R. SCHUETZE, W. HILLGER, and J. BLOCK Jun. 1986 178 p  
In GERMAN; ENGLISH summary Colloquium held in Brunswick, West Germany, 5 Jun. 1986  
(DFVLR-MITT-86-09; ISSN-0176-7739; ETN-86-98279) Avail:  
NTIS HC A09/MF A01; DFVLR, Cologne, West Germany DM 50

The observation of defects and their progression in carbon fiber reinforced plastics (CFRP) structures for damage mechanics analysis of primary structures in aerospace technology is treated. Nondestructive test methods, namely ultrasonic testing, acoustic emission analysis, X-ray techniques, and an optical reflection method are presented. All these techniques prove to be well suited for investigations of damage mechanics. ESA

**N87-14438#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Strukturmechanik.

**NONDESTRUCTIVE TESTS OF CARBON FIBER REINFORCED PLASTICS (CFRP) IN THE FRAMEWORK OF DAMAGE MECHANICS INVESTIGATIONS**

R. SCHUETZE In *its* Proceedings of a Structural Mechanics Colloquium of Nondestructive Testing of Fiber Reinforced Structures p 11-27 Jun. 1986 In GERMAN; ENGLISH summary  
Avail: NTIS HC A09/MF A01; DFVLR, Cologne, West Germany DM 50

Nondestructive testing of CFRP structures for damage mechanics investigations is discussed. The most important requirements for nondestructive testing procedures are high resolution and high reproducibility in order to get indications even of very small changes in the material between, e.g., two load levels. Among the large number of nondestructive testing methods, the ultrasonic test, acoustic emission, X-ray techniques, and the optical reflection method were chosen. The combination of all four methods provides nearly complete information of the state of damage of the material. ESA

**N87-14447#** Service Techniques des Programmes Aeronautiques, Paris (France). Section Materiaux.

**INFORMATION NOTICE ABOUT THE REPAIR OF COMPOSITE STRUCTURES [NOTE D'INFORMATION SUR LA REPARATION DES STRUCTURES EN COMPOSITES]**

M. JACQUELIN 11 Sep. 1985 31 p In FRENCH  
(STPA-42744; ETN-87-98580) Avail: NTIS HC A03/MF A01

The state of the art of composites repairing for military or private aircraft users is reviewed. The need for test laboratories with nondestructive test equipment, adequate personnel, and specific repairing materials is emphasized. ESA

**N87-14448#** Centre d'Essais Aeronautique Toulouse (France). Lab. d'Etudes de Materiaux non Metalliques.

**ELEMENTARY CHARACTERIZATION OF THE AS4/2220.3 HERCULES PREPREG Final Test Report [CARACTERISATION ELEMENTAIRE DU PREIMPREGNE AS4/2220.3 D'HERCULES INC.]**

11 Jun. 1986 51 p In FRENCH  
(CEAT-M4-475-000; ETN-87-98583) Avail: NTIS HC A04/MF A01

The properties of preimpregnated carbon-epoxy were measured in order to evaluate its utilization for aircraft composite structural elements. It is shown that in spite of advanced gelification it does not evolve after 1 month storage. Mechanical measurements reveal a rather low and temperature sensitive interlayer shear resistance (55 MPa at 120 C). ESA

## ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A87-16665****GALLERY OF FLUID MOTION. II**

H. L. REED (Arizona State University, Tempe) Physics of Fluids (ISSN 0031-9171), vol. 29, Sept. 1986, p. 2769-2780. refs

Winning photographs from the Third Annual Fluid-Mechanics Photo Contest held at the November 1985 meeting of the American Physical Society, Division of Fluid Dynamics, Tucson, Arizona, are presented. The photographs show a visualization of different boundary-layer transition mechanisms, formation of rollers in lubricating flows, shock interaction with a He-filled soap bubble, the breakdown of a leading-edge vortex on a delta wing, and splashing of laminar jets impinging on a solid surface. I.S.

**A87-16757****MICROCOMPUTER CONTROL OF AN ELECTRONICALLY COMMUTATED DC MOTOR**

M. A. EL-SHARKAWI, J. S. COLEMAN (Washington, University, Seattle), I. S. MEHDI, and D. L. SOMMER (Boeing Military Airplane Co., Seattle, WA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 320-325. Research supported by the Boeing Military Airplane Co. refs

A microcomputer control system for an electronically commutated dc motor (ECM) has been designed, built and tested. A 3-hp, 270-volt, samarium-cobalt brushless dc motor is controlled by an Intel 8086-based microcomputer. The main functions of the microcomputer are to control the speed of the motor, to provide forward or reverse rotation, to brake, and to protect the motor and its power electronic switching circuits from overcurrents. The necessary interface circuits were designed and built, and the system components have been integrated and tested. It is shown that the proposed ECM system with the microcomputer control operate the motor reliably over a wide range of speeds. The purpose of this effort is to develop the motorcontroller for driving electromechanical actuators for flight control and other aircraft applications. Author

**A87-16765****THE SECOND ELECTRONICS REVOLUTION - THE IMPACT POTENTIAL OF NEW POWER ELECTRONIC TECHNOLOGIES ON AIRCRAFT ACTUATION SYSTEMS**

J. R. LYFORD (General Electric Co., Binghamton, NY) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 386-390. refs

**A87-17184****CERAMICS - THE FABRICATION CHALLENGE**

E. BRISCOE (Fairey Tecramics, Ltd., Filleybrooks, England) (Institute of Metals and Institute of Ceramics, Meeting on Ceramics in Engines, London, England, Nov. 19, 1985) Materials Science and Technology (ISSN 0267-0836), vol. 2, Sept. 1986, p. 910-912.

Fabrication techniques for ceramics, which include slip casting, dry pressing, isostatic pressing, extrusion, injection molding, tape casting, flame spraying, and electrophoretic deposition, are described. The selection of the proper fabrication technique is dependent on the required component size and shape, component surface finish and dimensional tolerances, and cost. Two examples displaying the fabrication selection process for the manufacturing

of a cylinder liner and a turbocharger blade ring are presented.

I.F.

**A87-17417****VALVES FOR HIGH PRESSURE HYDRAULIC SYSTEMS**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Sept. 1986, p. 28-34.

Both the U.S. Air Force and Navy are planning to incorporate CTFE polymer fluid-employing 8000-psi hydraulic systems in their next-generation fighter aircraft. Attention is presently given to the valve designs that will be employed in these high pressure hydraulic systems. The valves considered are of the selector, bleeder, lock, restrictor, shutoff, spool, poppet, check, shuttle, priority, pilot, solenoid, electrohydraulic and reducing types. O.C.

**A87-17903\*# Florida Univ., Gainesville.****OPTIMUM STRUCTURAL SIZING OF CONVENTIONAL CANTILEVER AND JOINED WING CONFIGURATIONS USING EQUIVALENT BEAM MODELS**

P. HAJELA and J. L. CHEN (Florida, University, Gainesville,) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 10 p. refs (Contract NCA2-IR-240-401)

(AIAA PAPER 86-2653)

The present paper describes an approach for the optimum sizing of single and joined wing structures that is based on representing the built-up finite element model of the structure by an equivalent beam model. The low order beam model is computationally more efficient in an environment that requires repetitive analysis of several trial designs. The design procedure is implemented in a computer program that requires geometry and loading data typically available from an aerodynamic synthesis program, to create the finite element model of the lifting surface and an equivalent beam model. A fully stressed design procedure is used to obtain rapid estimates of the optimum structural weight for the beam model for a given geometry, and a qualitative description of the material distribution over the wing structure. The synthesis procedure is demonstrated for representative single wing and joined wing structures. Author

**A87-17910#****TRANSLATING SUPPORTABILITY REQUIREMENTS INTO DESIGN REALITY**

J. BUCHE and I. COHEN (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. (AIAA PAPER 86-2665)

This paper explores some of the principal issues in the integration of supportability into the design process. Roles of the contractor's design, supportability and management specialists and their government counterparts are discussed as they relate to logistics influence in design. Methods and processes by which weapon system logistics and readiness requirements are established, assessed, allocated to system elements and translated into specific design features are described. Tradeoff consideration, an approach to effective tradeoff criteria, and the progress of supportability issues through the program phases are identified with particular emphasis on the necessity for developing and maintaining an effective audit trail. Author

**A87-17911#****THE ROLE OF SUPPORTABILITY ENGINEERING IN THE DESIGN PROCESS**

H. D. HALL (Lockheed-Georgia Co., Marietta) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p.

(AIAA PAPER 86-2666)

This paper addresses the impact of supportability on the design process. Four basic questions are addressed in the paper: (1) how can an acceptable level of supportability be achieved, (2) how and why must supportability requirements be translated into design-to requirements, (3) at what point in the design process must supportability be considered, and (4) how do the 'supportability

engineers' prepare themselves to make the most impact on the design process. Author

**A87-17923#****CORRECTION FACTORS FOR MINER'S FATIGUE DAMAGE EQUATION DERIVED FROM C-130 FLEET AIRCRAFT FATIGUE CRACKS**

J. D. YOST (Bell Helicopter Textron, Fort Worth, TX) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. refs (AIAA PAPER 86-2684)

In 1968 many C-130 fleet aircraft had center wing section fatigue cracks that were converted to actual fatigue damage with a crack growth curve. The past history of each airplane was compiled in terms of flight-hours for each of nine missions. An equation was then computed using regression analysis, relating actual damage and flight-hours per mission, with its coefficients being damage per hour. These coefficients were recently used as dependent variables for determining the damage by load environment type: ground-air-ground, taxi, gust, and maneuver. Independent variables were the number of ground-air-ground per hour, number of takeoff and landings per hour times the ratio of runway roughness, percent of time in turbulence times the gust intensity factor, and maneuver damage. The percent of damage by loading source and the damage ratio (upper surface divided by lower) at the key wing station, WS 120, were computed. From these and C-130 cyclic test results, combined with B-52G/H and KC-135A data, it was then possible to calculate correction factors for Miner's damage equation. Author

**A87-17927#****TRANSLATING AIRCRAFT RELIABILITY AND MAINTAINABILITY INTO MEASURES OF OPERATIONAL EFFECTIVENESS**

D. C. DIETZ (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 6 p. (AIAA PAPER 86-2690)

This paper describes a numerical model for translating aircraft subsystem reliability and maintainability characteristics into measures of aircraft operational effectiveness. The model incorporates the impact of constraints on the availability of manpower resources required to accomplish subsystem repairs. Author

**A87-17949#****INTEGRATED DESIGN AND ANALYSIS OF ADVANCED AIRFOIL SHAPES FOR GAS TURBINE ENGINES**

B. A. HILL and P. J. ROONEY (Textron, Inc., Avco Lycoming Textron, Stratford, CT) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 5 p. (AIAA PAPER 86-2731)

An integral process in the mechanical design of gas turbine airfoils is the conversion of 'hot' or running geometry into 'cold' or as-manufactured geometry. New and advanced methods of design and analysis must be created that parallel new and technologically advanced turbine components. In particular, to achieve the high performance required of today's gas turbine engines, the industry is forced to design and manufacture increasingly complex airfoil shapes using advanced analysis and modeling techniques. This paper describes a method of integrating advanced, general purpose finite element analysis techniques in the mechanical design process. Author

**A87-17965#****EQUIVALENT LINEARIZATION OF A SQUEEZE FILM DAMPER**

S. CHEN and S. LIU (Northwestern Polytechnical University, Xian, People's Republic of China) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 108, Oct. 1986, p. 434-440. refs

The equivalent linearization of an intershaft squeeze film damper in a two shaft engine system is investigated. The two shaft centers

at the damper position are assumed to move in different elliptical offset orbits and at synchronous frequency with the unbalanced rotor (e.g., the high pressure rotor). The nonlinear damper force is resolved into two orthogonal components along the absolute coordinate directions and, in turn, each of these force components is supposed to be equivalent to the sum of an average force, a linear spring force, and a linear damping force in the corresponding direction. By using the method of equivalent linearization by harmonic balance, the six parameters of the equivalent forces, including two average forces, two equivalent spring coefficients, and two equivalent damping coefficients, are expressed analytically by the squeeze film forces and the assumed orbital motion of the two shaft centers at the damper position. Author

**A87-18183****INTERNATIONAL CONFERENCE ON STRUCTURAL ADHESIVES IN ENGINEERING, UNIVERSITY OF BRISTOL, ENGLAND, JULY 2-4, 1986, PROCEEDINGS**

Conference sponsored by IME, Plastics and Rubber Institute, Institution of Production Engineers, and Royal Aeronautical Society. London, Mechanical Engineering Publications, Ltd. (IMEchE Conference Publications 1986-6), 1986, 263 p. For individual items see A87-18184 to A87-18198.

Topics discussed include stress analysis concepts for adhesive bonding of aircraft primary structure, mechanics of bonded joints, criterion for mixed mode fracture in composite bonded joints, fatigue strength of bonded joints in CFRP, adhesive bonding of contaminated carbon fiber composites, and low-velocity impact inspection of bonded structures. Attention is also given to applications of epoxy and acrylic adhesives, adhesive selection, pressure-sensitive fastening systems in the motor industry, jointing techniques, uses of adhesives in civil engineering, and quality control of adhesive bonded joints. C.D.

**A87-18184****STRESS ANALYSIS CONCEPTS FOR ADHESIVE BONDING OF AIRCRAFT PRIMARY STRUCTURE**

R. B. KRIEGER (American Cyanamid Co., Havre de Grace, MD) IN: International Conference on Structural Adhesives in Engineering, Bristol, England, July 2-4, 1986, Proceedings. London, Mechanical Engineering Publications, Ltd., 1986, p. 1-10. refs

Concepts of stress analysis are examined for bonding of aircraft primary structures. Emphasis is on current instrumentation to provide vital data on adhesive shear stiffness. A simple bonded joint configuration is chosen for study and stress analysis: this skin doubler specimen is a bonded joint between an infinitely long skin and a doubler which is also infinitely long. The skin is loaded in tension and the adhesive transfers tension load into the doubler. It is seen that the maximum adhesive shear stress (at the doubler tip) and the distance required for the adhesive stress to fall to zero are driven by the stiffness of the glue line; the distance to zero adhesive shear is also dependent on adhesive stiffness change. Topics covered include: verification of stress analysis for skin-doubler specimen; shear stress-strain data for three adhesives on thick-adherend and skin-doubler specimens; and F-18 aircraft, bonded attachment of wing to fuselage. D.H.

**A87-18191****QUALITY CONTROL OF ADHESIVE BONDING IN THE MANUFACTURE OF AIRCRAFT STRUCTURES**

G. JACKSON (British Aerospace, PLC, Preston, England) and G. A. MARR (Lancashire Polytechnic, Preston, England) IN: International Conference on Structural Adhesives in Engineering, Bristol, England, July 2-4, 1986, Proceedings. London, Mechanical Engineering Publications, Ltd., 1986, p. 133-138.

The extensive use of adhesive bonding in the manufacture of critical aircraft structures has focused attention on the limitation of current N.D.T. methods to quantify joint strength. It is, however, recognized that N.D.T. alone cannot control adhesive bonding and must, therefore, take its place in a quality control program. This paper outlines the problems and introduces some routes to solutions which are being developed. Author

**A87-18195****STRUCTURAL APPLICATIONS OF ADHESIVES**

W. C. WAKE IN: International Conference on Structural Adhesives in Engineering, Bristol, England, July 2-4, 1986, Proceedings. London, Mechanical Engineering Publications, Ltd., 1986, p. 161-168. refs

There are applications in which adhesives replace other methods of fastening with only minimal change in design. Other applications involve situations open only to adhesive manufacture. The first case is shown by substituting adhesive for rivetting. Among examples of the second case are honeycomb panels, composite constructions and stress-contour thickening. Reasons for preferring adhesively bonded joints include reduction in peak stress and better dynamic fatigue characteristics. Examples are taken from civil engineering projects, aircraft manufacture, and helicopter blades.

Author

**A87-18562****MONOCOQUE, SANDWICH, AND COMPOSITE AEROSPACE STRUCTURES**

NICHOLAS HOFF, J. Lancaster, PA, Technomic Publishing Co., Inc., 1986, 591 p. refs

A collection is presented of the papers produced by Nicholas J. Hoff over the course of a career in which he prominently contributed to the development of design and analysis methods for lightweight shell structures applicable to vehicular, nautical, and aeronautical systems. These contributions to the theory of shell structures encompass monocoque cylinders, conical and spherical shells, the buckling of columns and frameworks, thermal effects on structures, creep effects, and the performance characteristics of sandwich and composite structures.

O.C.

**A87-18934#****DETERMINATION OF THE SEPARATION POINT IN LAMINAR BOUNDARY-LAYER FLOWS**

V. A. WEHRLE (CDC, Communications Research Centre, Ottawa, Canada) AIAA Journal (ISSN 0001-1452), vol. 24, Oct. 1986, p. 1636-1641. Previously cited in issue 07, p. 889, Accession no. A86-19695. refs

**A87-19071****A HIGHLY RELIABLE LAN PROTOCOL**

A. C. WEAVER (Virginia, University, Charlottesville) IEEE Journal on Selected Areas in Communications (ISSN 0733-8716), vol. SAC-4, Oct. 1986, p. 1181-1183. refs

As a research project for NASA's Langley Research Center, a variation on the military standard for avionics buses was developed to increase fault tolerance. The resulting protocol, called implicit token passing (ITP), replaces an explicit token with brief 'soundoff' messages from all nodes participating on the LAN. ITP features high throughput and bounded message delay, and achieves high reliability through tolerance of failed nodes and automatic resynchronization when failed nodes are revived. The protocol is ideally suited for a bus topology and fiber optic media.

Author

**A87-19218****MACHINE VISION INSPECTION OF COMBUSTOR HOLES**

A. R. HILL, JR. (Garrett Turbine Engine Co., Automation Group, Phoenix, AZ) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 189-195.

More valuable information can be gathered faster by means of machine vision inspection of toroidal gas turbine combustor liner holes than through visual pin gage inspection; in addition, it is found that machine vision is suited for in-process inspection and adaptive control of the hole-making process. The most problematic aspect of this inspection method involves the quantification and control of the inspection error source. Attention is presently given to the application details of robotic combustor hole inspection methods.

O.C.

**A87-19219****ROTATIONAL MOLDING OF HIGH TEMPERATURE THERMOPLASTICS**

R. A. LOFLAND (McDonnell Douglas Helicopter Co., Culver City, CA) and R. GARDINER (RMB Products, Simi Valley, CA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 197-203.

The McDonnell Douglas AH-64A 'Apache' Attack Helicopter has within its many systems an area called the Pressurized Air System. This system includes complex manifolds and tube assemblies which are subjected to temperatures of up to 500 degrees F and pressures of 30 PSI. Many of these are welded aluminum fabrication, and are relatively expensive to produce. This paper explores the fabrication of a typical complex pressurized air system manifold using the rotational molding process. The paper will include material selection, parts design, tool design, tool fabrication, part fabrication, testing and cost advantages of this process.

Author

**A87-19274****SAND SEPARATOR EFFICIENCY CALCULATION FOR THE JVX TILT ROTOR AIRCRAFT INLET**

J. J. KIM, M. D. BREER (Boeing Military Airplane Co., Wichita, KS), J. GASS (Boeing Computer Services Co., Wichita, KS), and D. KNEELING (Boeing Military Airplane Co., Seattle, WA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 2. Alexandria, VA, American Helicopter Society, 1986, p. 955-965. Research supported by the Boeing Military Airplane Co. refs

A computational method is presented to evaluate the sand separator effectiveness of the JVX (V-22 Osprey) inertial particle separator engine inlet. State-of-the-art computational fluid dynamics (CFD) codes and patch parametric mathematical modeling of the inlet geometry are applied to compute sand particle trajectories about the inlet. Results show good sand separation characteristics of the inlet design recommended for full scale development. Detailed 3-dimensional computer graphics simulation of sand particle motion is performed which demonstrates the interactive design/analysis capability of the method. By analyzing trajectories of water droplets, instead of sand particles, this method is directly applicable to icing analysis problems of helicopter and V/STOL aircraft engine inlets.

Author

**A87-19507****DYNAMIC STABILITY THRESHOLD OF CONTACTING MECHANICAL SEALS**

A. LIPSCHITZ (EG&G Sealol, Inc., Warwick, RI) ASLE and ASME, Joint Tribology Conference, Pittsburgh, PA, Oct. 20-22, 1986. 10 p. refs

(ASLE PREPRINT 86-TC-3B-2)

The dynamic behavior of contacting mechanical face seals is analyzed. Stiffness and damping coefficients of the secondary seal, face friction, and seal inertia in the presence of eccentric operation and wobbling rotor are fully considered. It is shown that eccentric installation of the seal relative to the rotor is a major vibration-inducing mechanism and should be minimized. A stability criterion is established for the dynamic angular tilting moments. This provides necessary parameters needed for the design of a stable seal.

Author

**A87-19526#****THE ROTOR DYNAMIC COEFFICIENTS OF CONED-FACE MECHANICAL SEALS WITH INWARD OR OUTWARD FLOW**

I. GREEN (Georgia Institute of Technology, Atlanta) ASME and ASLE, Joint Tribology Conference, Pittsburgh, PA, Oct. 20-22, 1986. 7 p. refs

(ASME PAPER 86-TRIB-6)

The linearized fluid film dynamic coefficients, i.e., stiffness and damping, of flexibly-mounted rotor noncontacting mechanical face seals are found. The coefficients are derived from a previous study where the flexibly mounted element was the stator. The two cases of inward and outward flows, both having converging

gaps in the direction of flow, are analyzed for the two mounting configurations, and it is found that the later case possesses higher angular stiffness. Author

**A87-19530\*# Texas A&M Univ., College Station.**  
**TEST RESULTS FOR SAWTOOTH-PATTERN DAMPER SEALS - LEAKAGE AND ROTORDYNAMIC COEFFICIENTS**

D. CHILDS (Texas A & M University, College Station) and F. GARCIA (NASA, Marshall Space Flight Center, Huntsville, AL) ASME and ASLE, Joint Tribology Conference, Pittsburgh, PA, Oct. 20-22, 1986. 5 p. refs (Contract NAS8-33716) (ASME PAPER 86-TRIB-21)

Test results consisting of direct and transverse force coefficients are presented for eleven sawtooth-pattern damper-seal configurations. The designation 'damper' seal refers to a seal which uses a deliberately roughened stator and smooth rotor to increase the net seal damping force. The designation 'sawtooth-pattern' refers to a stator-roughness pattern whose cross section normal to the axis of the seal resembles saw teeth with the teeth direction opposing fluid motion in the direction of shaft rotation. The sawtooth pattern yields axial grooves in the stator which are interrupted by spacer elements which act as flow constrictions or 'dams'. Sawtooth-pattern seals had more damping than smooth seals but less than the round-hole-pattern seals tested previously. If damping is sacrificed, sawtooth-pattern seals can be designed to leak less than round-hole-pattern seals. Author

**A87-19595**  
**HIGH-X-RAY FLUX, HIGH-CONTRAST RADIOGRAPHY OF CARBON FIBER-REINFORCED EPOXY AIRCRAFT STRUCTURES**

I. RUDICH, L. LESENSKY, and F. KAPELEWSKI (Machlett Laboratories, Inc., Stamford, CT) Materials Evaluation (ISSN 0025-5327), vol. 44, Sept. 1986, p. 1158, 1159, 1162 (3 ff.).

Radiographic NDE techniques for epoxy-matrix CFRP aircraft components are examined in a tutorial review. Consideration is given to radiation sources and attenuators, X-ray radiated power, absorption and scattering, distance effects, film or receptor coverage, resolution, contrast, the characteristic features and performance of specially designed X-ray tubes, procedures for deriving power-output spectra, and the total radiated power available at the receptor. It is shown that excellent resolution and fault detection can be obtained at 10-15 kV using a 1.5-kW tube with a 1.5-mm focal spot. T.K.

**N87-13589# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).**  
**ACTIVITIES REPORT IN MATERIALS AND CONSTRUCTION**

**Annual Report, 1985 [FORSCHUNGSBEREICH WERKSTOFFE UND BAUWEISEN]**

1985 114 p. In GERMAN (ISSN-0174-3910; ETN-86-98280) Avail: NTIS HC A06/MF A01

Research in materials and construction methods is presented. Structural mechanics, aeroelasticity, and space simulation are covered. ESA

**N87-13616# Mitre Corp., McLean, Va.**  
**MONOPOLE ELEMENT AT THE CENTER OF A CIRCULAR GROUNDPLANE OF ARBITRARY RADIUS. VOLUME 2: APPENDICES Final Report**

M. M. WEINER, S. P. CRUZE, C. C. LI, and W. J. WILSON 31 Mar. 1986 218 p (Contract F19628-84-C-0001) (AD-A171228; MTR-9622-VOL-2; ESD-TR-86-241-VOL-2) Avail: NTIS HC A10/MF A01 CSCL 20N

The input impedance, field strengths, and directive gain of a monopole element at the center of a circular groundplane in free space are determined for arbitrary groundplane radius, element length, and element radius. Numerical results are obtained by using various models and are compared with measurements. Particular emphasis is given to groundplane radii that are small or comparable to a wavelength. The models include the induced EMF method,

integral equation method, method of moments, oblate spheroidal wave functions, variational method, the method of moments combined with the geometric theory of diffraction, and the method of images. This volume contains the computer printouts of directive gain and the listings of the computer programs for the various models. GRA

**N87-13621# Georgia Tech Research Inst., Atlanta.**  
**COMPACT ANTENNA RANGE ANALYSIS Final Report, Sep. 1984 - Sep. 1985**

R. W. MOODY, O. D. ASBELL, and E. B. JOY Jan. 1986 61 p (Contract DAEA18-84-C-0050; DA PROJ. 1T6-65702-D-625) (AD-A171556; USAEPG-FR-1289) Avail: NTIS HC A04/MF A01 CSCL 14B

This preliminary design study (methodology investigation) established the feasibility and cost of the reflector for an outdoor compact range with 50 foot diameter quiet zone. The U.S. Army at Ft. Huachuca, Arizona would use the range to measure patterns of microwave antennas mounted on vehicles and aircraft. Considerations included reflector configuration, size, focal length, surface accuracy, edge treatment, feed, quiet zone quality, manufacturing technology, erection, alignment and cost. GRA

**N87-13661\*# General Motors Corp., Indianapolis, Ind. Allison Gas Turbine Div.**

**TURBINE VANE EXTERNAL HEAT TRANSFER. VOLUME 2. NUMERICAL SOLUTIONS OF THE NAVIER-STOKES EQUATIONS FOR TWO- AND THREE-DIMENSIONAL TURBINE CASCADES WITH HEAT TRANSFER Final Report**

R. J. YANG, B. C. WEINBERG, S. J. SHAMROTH, and H. MCDONALD Jul. 1985 160 p (Contract NAS3-23695)

(NASA-CR-174828; NAS 1.26:174828; ALLISON-EDR-11984)

Avail: NTIS HC A08/MF A01 CSCL 20D

The application of the time-dependent ensemble-averaged Navier-Stokes equations to transonic turbine cascade flow fields was examined. In particular, efforts focused on an assessment of the procedure in conjunction with a suitable turbulence model to calculate steady turbine flow fields using an O-type coordinate system. Three cascade configurations were considered. Comparisons were made between the predicted and measured surface pressures and heat transfer distributions wherever available. In general, the pressure predictions were in good agreement with the data. Heat transfer calculations also showed good agreement when an empirical transition model was used. However, further work in the development of laminar-turbulent transitional models is indicated. The calculations showed most of the known features associated with turbine cascade flow fields. These results indicate the ability of the Navier-Stokes analysis to predict, in reasonable amounts of computation time, the surface pressure distribution, heat transfer rates, and viscous flow development for turbine cascades operating at realistic conditions. Author

**N87-13663\*# National Academy of Sciences - National Research Council, Washington, D. C. Committee to Assess Current Capabilities and Future Directions in Computational Fluid Dynamics.**

**CURRENT CAPABILITIES AND FUTURE DIRECTIONS IN COMPUTATIONAL FLUID DYNAMICS**

1986 107 p (Contract NASW-4003) (NASA-CR-179946; NAS 1.26:179946) Avail: NTIS HC A06/MF A01 CSCL 20D

A summary of significant findings is given, followed by specific recommendations for future directions of emphasis for computational fluid dynamics development. The discussion is organized into three application areas: external aerodynamics, hypersonics, and propulsion - and followed by a turbulence modeling synopsis. Author



**N87-13664\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AEROTHERMAL TESTS OF SPHERICAL DOME PROTUBERANCES ON A FLAT PLATE AT A MACH NUMBER OF 6.5 OF 6.5**

C. E. GLASS and L. R. HUNT Dec. 1986 61 p  
(NASA-TP-2631; L-16160; NAS 1.60:2631) Avail: NTIS HC A04/MF A01 CSCL 20D

Aerothermal tests were conducted in the Langley 8-Foot High-Temperature Tunnel at a Mach number of 6.5 on a series of spherical dome protuberances mounted on a flat-plate test apparatus. Detailed surface pressure and heating-rate distributions were obtained for various dome heights and diameters submerged in both laminar and turbulent boundary layers including a baseline geometric condition representing a thermally bowed metallic thermal protection system (TPS) tile. The present results indicated that the surface pressures on the domes were increased on the windward surface and reduced on the leeward surface as predicted by linearized small-perturbation theory, and the distributions were only moderately affected by boundary-layer variations. Surface heating rates for turbulent flow increased on the windward surface and decreased on the leeward surface similar to the pressure; but for laminar boundary layers, the heating rates remained high on the leeward surface, probably due to local transition. Transitional flow effects cause heat load augmentation to increase by 30 percent for the maximum dome height in a laminar boundary layer. However, the corresponding augmentation for a dome with a height of 0.1 in. and a diameter of 14 in. representative of a bowed TPS tile was 14 percent or less for either a laminar or turbulent boundary layer.

Author

**N87-13755\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**EFFECT OF DESIGN VARIABLES, TEMPERATURE GRADIENTS AND SPEED OF LIFE AND RELIABILITY OF A ROTATING DISK**

E. V. ZARETSKY, T. E. SMITH (Sverdrup Technology, Inc., Cleveland, Ohio), and R. AUGUST 1986 26 p Proposed for presentation at the 2nd Thermal Engineering Conference, Honolulu, Hawaii, 22-27 Mar. 1987; sponsored by ASME and JSME (NASA-TM-88883; E-3291; NAS 1.15:88883) Avail: NTIS HC A03/MF A01 CSCL 94D

A generalized methodology to predict the fatigue life and reliability of a rotating disk such as used for aircraft engine turbines and compressors is advanced. The approach incorporates the computed life of elemental stress volumes to predict system life and reliability. Disk speed and thermal gradients as well as design variables such as disk diameter and thickness and bolt hole size, number and location are considered.

Author

**N87-13757#** Aeronautical Research Labs., Melbourne (Australia).

**EXAMINATION OF A TECHNIQUE FOR THE EARLY DETECTION OF FAILURE IN GEARS BY SIGNAL PROCESSING OF THE TIME DOMAIN AVERAGE OF THE MESHING VIBRATION**

P. D. MCFADDEN Apr. 1986 26 p  
(AD-A171031; ARL/AERO-PROP-TM-434) Avail: NTIS HC A03/MF A01 CSCL 13I

An existing technique for the signal processing to the time domain average of the tooth meshing vibration of gears is examined with application to the early detection of failure. It is shown that the regular signal extracted from the time domain average of the gear vibration by the elimination of the fundamental and harmonics of the tooth meshing frequency forms the time domain average of the vibration of a single tooth. The residual signal which is obtained by subtracting the regular signal from the original time domain average gives the departures of the vibration from the average. Numerical and practical examples are given.

Author (GRA)

**N87-13789\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF WINGLET ON TRANSONIC FLUTTER CHARACTERISTICS OF A CANTILEVERED TWIN-ENGINE-TRANSPORT WING MODEL**

C. L. RUHLIN, K. G. BHATIA (Boeing Commercial Airplane Co., Seattle, Wash.), and K. S. NAGARAJA Dec. 1986 77 p  
(NASA-TP-2627; L-16095; NAS 1.60:2627) Avail: NTIS HC A05/MF A01 CSCL 20K

A transonic model and a low-speed model were flutter tested in the Langley Transonic Dynamics Tunnel at Mach numbers up to 0.90. Transonic flutter boundaries were measured for 10 different model configurations, which included variations in wing fuel, nacelle pylon stiffness, and wingtip configuration. The winglet effects were evaluated by testing the transonic model, having a specific wing fuel and nacelle pylon stiffness, with each of three wingtips, a nominal tip, a winglet, and a nominal tip ballasted to simulate the winglet mass. The addition of the winglet substantially reduced the flutter speed of the wing at transonic Mach numbers. The winglet effect was configuration-dependent and was primarily due to winglet aerodynamics rather than mass. Flutter analyses using modified strip-theory aerodynamics (experimentally weighted) correlated reasonably well with test results. The four transonic flutter mechanisms predicted by analysis were obtained experimentally. The analysis satisfactorily predicted the mass-density-ratio effects on subsonic flutter obtained using the low-speed model. Additional analyses were made to determine the flutter sensitivity to several parameters at transonic speeds.

Author

**N87-13795\*#** Textron Bell Helicopter, Fort Worth, Tex.

**SUMMARY OF AH-1G FLIGHT VIBRATION DATA FOR VALIDATION OF COUPLED ROTOR-FUSELAGE ANALYSES**

**Final Report**

R. V. DOMPKA and J. D. CRONKHITE Nov. 1986 151 p  
(Contract NAS1-17496)  
(NASA-CR-178160; NAS 1.26:178160; BHT-699-099-217) Avail: NTIS HC A08/MF A01 CSCL 46E

Under a NASA research program designated DAMVIBS (Design Analysis Methods for VIBrationS), four U. S. helicopter industry participants (Bell Helicopter, Boeing Vertol, McDonnell Douglas Helicopter, and Sikorsky Aircraft) are to apply existing analytical methods for calculating coupled rotor-fuselage vibrations of the AH-1G helicopter for correlation with flight test data from an AH-1G Operational Load Survey (OLS) test program. Bell Helicopter, as the manufacturer of the AH-1G, was asked to provide pertinent rotor data and to collect the OLS flight vibration data needed to perform the correlations. The analytical representation of the fuselage structure is based on a NASTRAN finite element model (FEM) developed by Bell which has been extensively documented and correlated with ground vibration tests. The AH-1G FEM was provided to each of the participants for use in their coupled rotor-fuselage analyses. This report describes the AH-1G OLS flight test program and provides the flight conditions and measured vibration data to be used by each participant in their correlation effort. In addition, the mechanical, structural, inertial and aerodynamic data for the AH-1G two-bladed teetering main rotor system are presented. Furthermore, modifications to the NASTRAN FEM of the fuselage structure that are necessary to make it compatible with the OLS test article are described. The AH-1G OLS flight test data was found to be well documented and provide a sound basis for evaluating currently existing analysis methods used for calculation of coupled rotor-fuselage vibrations.

Author

**N87-14257#** National Aerospace Lab., Tokyo (Japan).

**DEVELOPMENT OF THE HIGHLY LOADED AXIAL FLOW TURBINE AIRFOILS, MAKING USE OF THE IMPROVED**



**INVERSE CHANNEL FLOW DESIGN METHOD**

K. HASHIMOTO *In its* Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 77-87 Nov. 1985 In JAPANESE; ENGLISH summary  
 Avail: NTIS HC A12/MF A01

To reduce the number of the turbine airfoils or the solidity as far as possible without increasing energy loss, a study of highly loaded turbine airfoils was conducted. These airfoils were designed for the typical velocity diagrams of the first and second stages of a jet engine low pressure turbine. With regard to the design procedures, an improved inverse method, and also a boundary layer analysis technique were employed to optimize the airfoil shapes. These airfoils, and state-of-the-art aft loaded conventional airfoils designed for almost equivalent velocity diagrams were tested in the high speed cascade wind tunnel. The airfoils showed lower kinetic energy loss coefficient characteristics and wider useful incidence ranges over the wider range extended to the high subsonic regime compared with the aft loaded ones, in spite of their higher loading. In addition to some main parts of the design procedures, theoretical and experimental results are discussed.

Author

**N87-14263#** National Aerospace Lab., Tokyo (Japan).

**APPLICATION OF THE E SUP N METHOD TO CALCULATIONS OF LAMINAR FLOW CONTROL**

Y. ISHIDA and N. ITOH *In its* Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 131-138 Nov. 1985 In JAPANESE; ENGLISH summary  
 Avail: NTIS HC A12/MF A01

The e sup N method was applied to two-dimensional, incompressible laminar boundary layers with and without suction with the aim of developing an aerodynamic design method for a laminar flow control airfoil. The method consisted of an airfoil, boundary layer and e sup N codes, respectively. The airfoil code used the vortex singularity method and the boundary layer code Keller's Box method. In the e sup N code, the Orr-Sommerfeld equation was solved spatially with a given fundamental flow by the Itoh method and the growth rate ( $\alpha_{sub i}$ ) was integrated from the neutral point to an arbitrary downstream point, which gave the total amplification of the disturbance. A transition point was predicted by the point at which the total amplification became e sup N. As an example of the calculation, the laminar boundary layer over the surface of the NACA0012 airfoil with the suction velocity determined by the Michel criterion which could maintain the laminar flow over a full chord length was tested to confirm the very strong stabilizing effect of the suction. The result showed that both the Michel and the e sup N methods agree well qualitatively, but some uncertainty remains about quantitative agreement.

Author

**N87-14269#** National Aerospace Lab., Tokyo (Japan).

**COMPUTATIONS OF TWO- AND THREE-DIMENSIONAL FLOWS USING AN ADAPTIVE MESH**

K. NAKAHASHI *In its* Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 197-207 Nov. 1985 In JAPANESE; ENGLISH summary  
 Avail: NTIS HC A12/MF A01

Two- and three-dimensional, steady and unsteady viscous flow fields are numerically simulated by solving the Navier-Stokes equations. A solution-adaptive-grid method is used to redistribute the grid points so as to improve the resolution of shock waves and shear layers without increasing the number of grid points. Flow fields considered include two-dimensional transonic flows about airfoils, two- and three-dimensional supersonic flow past an aerodynamic afterbody with a propulsive jet, supersonic flow over a blunt fin mounted on a wall, and supersonic flow over a bump. The computed results demonstrate a significant improvement in accuracy and quality of the solutions owing to the solution-adaptive mesh.

Author

**N87-14673\*#** National Aeronautics and Space Administration, Washington, D.C.

**STUDY OF DOUBLE EXPOSURE HOLOGRAPHY OF THE 3-DIMENSIONAL CHARACTER OF THE FLOW AROUND AN AIRFOIL PROFILE IN A WIND TUNNEL**

G. HEID and M. STANISLAS Sep. 1986 39 p Transl. into ENGLISH of "Etude par Holographie a Double Exposition du Caractere Tridimensionnel de l'Ecoulement Autour d'Un Profil d'Aile en Soufflerie" Lille, France, 3 Jul. 1980 p 1-34 Translation was announced as N82-22474 Transl. by Kanner (Leo) Associates, Redwood City, Calif. Original document prepared by Inst. de Mecanique des Fluides de Lille, France  
 (Contract NASW-4005)

(NASA-TM-88486; NAS 1.15:88486; REPT-80/31) Avail: NTIS HC A02/MF A01 CSCL 82B

The tridimensional character of the flow around a profile placed between walls is demonstrated and the incidence induced with the assistance of measurements of velocities by double exposure holography is evaluated. The values obtained by the theory of Menard are compared satisfactorily to the values obtained by this experiment.

E.R.

**N87-14682#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Systemtechnik und Navigation.

**LABORATORY TESTS OF THE SENSORS OF THE STEINHEIL-LEAR SIEGLER STRAPDOWN MEASUREMENT UNIT MODEL 1903-SB FOR MODEL ATTITUDE MEASUREMENTS IN A WIND TUNNEL**

V. WETZIG and E. LUEBECK Apr. 1986 68 p In GERMAN; ENGLISH summary

(DFVLR-MITT-86-15; ISSN-0176-7739; ETN-86-98753) Avail:

NTIS HC A04/MF A01; DFVLR, Cologne, West Germany DM 26

Laboratory tests of the sensors for the Model Attitude Measurement System (MAMS) were performed. The sensor units, the test equipment, and the data acquisition are discussed. The sensor tests included rate tests for the investigation of the gyroscope scale factors and measuring axis misalignments, multiposition tests to determine constant and g-dependent gyroscope drift and to calibrate accelerometers, as well as stability tests to evaluate gyroscope drift variations. The results are given in tables with coefficients for error compensation, and with indications concerning short and longterm variations of the coefficients and measured values.

ESA

**N87-14721#** Societe Nationale Industrielle Aerospatiale, Suresnes (France). Direction Centrale de la Qualite.

**FAULT DETECTION SENSITIVITY IN THICK LIGHT ALLOY SPECIMENS, TEST REPORT [SENSIBILITE DE DETECTION DES DEFAUTS DANS LES PIECES EN ALLIAGES LEGERES DE FORTES EPAISSEURS]**

G. HILAIRE and D. LECURU 19 Jan. 1986 95 p In FRENCH (Contract STPA-84-96-010)

(REPT-47-084/F; ETN-86-98429) Avail: NTIS HC A05/MF A01

Crack length detection sensitivity using ultrasonic and Eddy current methods is studied. Cracks around riveted joints in light alloy junctions used in aircraft construction are considered. The detection probability curves were obtained by analyzing the data produced by 11 operators examining 400 rivets using both methods. It is shown that the 95% confidence limit is 3.5 mm for ultrasound and 6 mm for Eddy currents. A multiple inspection using both methods and three operators can eliminate detection errors and assures the detection at a 3.7 mm length.

ESA

**N87-14729\*** National Aeronautics and Space Administration, Washington, D.C.

**ON CONTACT PROBLEMS OF ELASTICITY THEORY**

A. I. KALANDIYA Oct. 1986 20 p Transl. into ENGLISH from "K Kontaknym Zadachim Teorii Uprugosti" IN: Prikladnaya Matematika i Mekhanika (Moscow, USSR), v. 21, no. 3, 1957 p 389-398 Transl. by The Corporate Word, Inc., Pittsburgh, Pa. (Contract NASW-4006) (NASA-TM-88491; NAS 1.15:88491) Avail: NTIS HC A02/MF A01 CSCL 46E

Certain contact problems are reviewed in the two-dimensional theory of elasticity when round bodies touch without friction along most of the boundary and, therefore, Herz' hypothesis on the smallness of the contact area cannot be used. Fundamental equations were derived coinciding externally with the equation in the theory of a finite-span wing with unknown parameter. These equations are solved using Multhopp's well-known technique, and numerical calculations are performed in specific examples.

Author

## 13

### GEOSCIENCES

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A87-16599#**

**AIRCRAFT MEASUREMENTS OF MEDIUM-RANGE TRANSPORT OF AIR POLLUTANTS OVER COMPLEX TERRAIN**

T. TOYA, F. KIMURA, and N. MURAYAMA (Meteorological Research Institute, Tsukuba, Japan) Meteorological Society of Japan, Journal (ISSN 0026-1165), vol. 64, June 1986, p. 431-442. Research sponsored by the Japan Environmental Agency. refs

A series of aircraft measurements of the three-dimensional distribution of air pollutants and meteorological elements was conducted during the summers of 1980, 1981, and 1982 in the Seto Inland Sea area of Japan in order to examine the medium-range transport processes due to local circulations. The data show that polluted air is horizontally distributed over almost all of the Seto Sea and is confined to levels below 1000 m in the early morning. The polluted air is transported to upper levels up to 3000 m in the evening by upslope winds and/or the sea breeze on the Shikoku side of the Seto Sea. Developed cumulus clouds over the mountains seem to contribute to the vertical transport of ozone and the scavenging of aerosols.

Author

**A87-18828**

**STRUCTURE OF AIR STREAMS BELOW CUMULONIMBUS CLOUDS [O STRUKTURE VOZDUSHNYKH POTOKOV POD KUCHEVO-DOZHDEVYMI OBLAKAMI]**

M. S. SHELKOVNIKOV IN: Diagnostics and forecasting of convective precipitation on the basis of meteorological-radar and satellite data. Leningrad, Gidrometeoizdat, 1985, p. 53-59. In Russian. refs

Wind-velocity and temperature profiles, wind shear, descending air motions, and turbulence below cumulonimbus clouds were studied on the basis of observations with radiosondes and the TU-134 aircraft. It is shown that conditions hazardous for the takeoff and landing of aircraft can often arise in the lower 100-meter layer between cumulonimbus clouds due to significant (greater than 12 m/s) wind shear and turbulence.

B.J.

**N87-14766#** Analytic Sciences Corp., Reading, Mass.

**AIDED-AIRBORNE GRAVITY GRADIOMETER SURVEY SYSTEM (GGSS) STUDY Final Report, Sep. 1983 - Sep. 1985**

S. J. BRZEZOWSKI and R. C. MERENYI Mar. 1986 132 p (Contract F19628-83-C-0146) (AD-A170749; TASC-TR-4769-2; AFGL-TR-86-0059) Avail: NTIS HC A07/MF A01 CSCL 17G

Several mechanization variants of the GGSS baseline configuration have been analyzed to assure an optimal and robust design and to establish confidence in the various navigation back-up modes. The analysis determined the current and anticipated performance of several sensors, individually and then in appropriate combination with the GGSS. Until more of the full Global Positioning System (GPS) constellation is in place, the currently planned precise reference clock and altimeter aides are capable of providing the increased visibility intervals and navigation accuracies required for GGSS airborne testing and initial survey operations. Moving-receiver radio interferometry to GPS is the most promising approach for satisfying the stringent navigation accuracies which may be required for GGSS surface testing. Furthermore, an improved measurement of gravity can be attained by augmenting a GGSS aiding gravimeter with interferometrically derived position and velocity.

GRA

**N87-14780#** Civil Aviation Authority, London (England). Chief Scientist's Div.

**UNITED KINGDOM AIRCRAFT NOISE INDEX STUDY: MAIN REPORT**

P. BROOKER, J. B. CRITCHLEY, D. J. MONKMAN, and C. RICHMOND Oct. 1984 231 p Prepared for Department of Transport, England (DR-8402; ETN-86-98593) Avail: Issuing Activity

The United Kingdom aircraft Noise and Number Index (NNI) was reassessed via noise measurements and questionnaires. Results confirm the usefulness of the Guttman annoyance scale. Noise events below 80 PNdB should be included in the index. A good fit to disturbance responses is given by 24 hr Leq, i.e., average noise over 24 hr. It is suggested that 55 Leq represent the onset of community disturbance, and 70 Leq a point of high disturbance. Continued use of NNI could lead to problems by underestimating the effect of less noisy aircraft, but arriving in greater numbers.

ESA

**N87-14781** Civil Aviation Authority, London (England).

**NOISE DISTURBANCE AT NIGHT NEAR HEATHROW AND GATWICK AIRPORTS: 1984 CHECK STUDY**

P. BROOKER 1986 79 p Sponsored by the Department of Transport, England (DR-8513; ETN-87-98594) Avail: Issuing Activity

Sleep disturbance near London airports in 1984 was compared with results for 1979. The comparison confirms that the Leq measure of noise average is a good aircraft noise disturbance measure for evening and night. There is a stronger increase, with Leq, in aircraft attributed disturbance than in the total disturbance reported. In the original study there were indications of increased total disturbance at 65 Leq plus. Improvements in the aircraft noise climate make these difficult to detect. The total number of movements at night does not influence disturbance strongly. The noisier flights, which contribute most to the Leq noise energy, appear to determine reaction.

ESA

**N87-14782** Civil Aviation Authority, London (England). Chief Scientist's Div.

**CEC JOINT STUDY OF COMMUNITY RESPONSE TO AIRCRAFT NOISE 1984: MAIN REPORT. THE INFLUENCE OF RESIDUAL NOISE ON DISTURBANCE FROM AIRCRAFT NOISE**

I. D. DIAMOND, J. G. WALKER, J. B. CRITCHLEY, and G. C. RICHMOND Jul. 1986 97 p Sponsored by the Commission of the European Communities and the UK Dept. of Transport Prepared in cooperation with Southampton Univ., England (DR-8601; ETN-87-98595) Avail: Issuing Activity

The influence of background noise on reported annoyance caused by aircraft noise near a regional airport was assessed.

The validity of aircraft noise indices was studied. Attitude scales as measures of disturbance were examined. A methodology for studies of community annoyance by environmental noise was derived. Results show no clear evidence that the disturbance due to aircraft noise is influenced by background noise. The Leq measure of aircraft noise is recommended. Simpler scales than the Guttman can be used to quantify disturbance. ESA

**N87-14792#** Pennsylvania State Univ., University Park. Dept. of Mineral Engineering.

**A STUDY TO MONITOR MICROSEISMIC ACTIVITY TO DETECT SINKHOLES Final Report**

H. R. HARDY, JR., R. M. BELESKY, M. MRUGALA, E. J. KIMBLE, and M. E. HAGER Jul. 1986 200 p

(Contract DTFA01-84-C-0005)

(DOT/FAA/PM-86/34) Avail: NTIS HC A09/MF A01

A research program was undertaken at Capital City Airport, New Cumberland, Pennsylvania to evaluate the feasibility of using seismic and acoustic emission/microseismic (AE/MS) techniques as a means of locating sinkhole-prone areas and monitoring current sinkhole stability. The report includes a review of the Capital City Airport sinkhole problem; a brief review of sinkhole phenomena and possible techniques for sinkhole detection and monitoring; a detailed description of the field studies carried out at the Capital City Airport site; a sinkhole monitoring philosophy based on the results of the airport studies; and an outline of additional studies required for the development of a prototype sinkhole-monitoring system. The results indicate that a combination of seismic and AE/MS techniques provide a feasible method for sinkhole detection and stability monitoring. Seismic techniques based on surface-wave attenuation provide a valid and convenient method for delineating sinkhole-prone areas. Conventional, low-frequency AE/MS techniques have been found satisfactory for locating simulated sinkhole activity. The location of AE/MS activity using zonal techniques was found to be very applicable to the problem of sinkhole location. However, high, rather than low, frequency AE/MS techniques may be more suitable for monitoring at such sites due to the inherent background noise. Preliminary laboratory studies associated with the development of dual-transducer waveguide systems for detecting AE/MS activity under runway pavements and in infield areas were encouraging. Author

**N87-14806#** National Oceanic and Atmospheric Administration, Boulder, Colo. Wave Propagation Lab.

**REMOTE DETECTION OF AIRCRAFT ICING CONDITIONS USING MICROWAVE RADIOMETERS**

M. T. DECKER, I. A. P. FOTINO, and J. A. SCHROEDER Jun. 1986 46 p

(PB86-229507; NOAA-TM-ERL-WPL-137) Avail: NTIS HC A03/MF A01 CSCL 04B

The potential role of ground-based remote sensors in the detection of atmospheric conditions conducive to aircraft icing is evaluated. Measurements of liquid water along a line of sight and profiles of atmospheric temperature were made by microwave radiometers located at Stapleton International Airport, Denver, Colorado. Radiometer data and sky cover observations for a 2-yr period were correlated with icing occurrences reported by aircraft pilots in the area. GRA

## MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A87-16422**

**ON OPTIMAL PERIODIC CONTROL AND NESTED OPTIMIZATION PROBLEMS**

F. COLONIUS (Bremen, Universitaet, West Germany) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 50, Sept. 1986, p. 525-533. DFG-supported research. refs (Contract AF-AFOSR-84-0398)

A minimization problem for a functional on a convex subset C of a normed linear space is considered. Under certain hypotheses, optimality in a certain subset of C implies the validity of first-order necessary optimality conditions for the problem in C. The result is applied to a problem in optimal periodic control of neutral functional differential equations. Author

**A87-16682**

**AN ARCHITECTURE FOR CONSIDERATION OF MULTIPLE FAULTS**

M. C. MALETZ (Inference Corp., Los Angeles, CA) IN: The engineering of knowledge-based systems; Proceedings of the Second Conference on Artificial Intelligence Applications, Miami Beach, FL, December 11-13, 1985. Washington, DC, IEEE Computer Society Press, 1985, p. 60-67. refs

A context graphs architecture is presented for fault diagnostic systems which reason from symptoms and tests to suspected faults. The rooted, directed, acyclic graphs (DAG) feature directional arcs which indicate parent-child relationships for tracking fact inheritance across the graphs. Root contexts have no parents, while all other contexts have one or more parents. The architecture permits use of heuristic search strategies through the space of possible faults. A 'merge' context is described which involves finding unique solutions for a particular context (fault) by tracking a distinct set of ancestors. Implementation of such an architecture is illustrated with a diagnostic system for Shuttle simulation hardware. M.S.K.

**A87-16733**

**THE HIGH SPEED INTERCONNECT SYSTEM**

S. C. ANDERSEN (Sperry Computer Systems, Saint Paul, MN) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 100-110.

This paper describes a proprietary, second generation High Speed Interconnect System (HSIS) developed during 1985 as part of a cooperative Internal Research and Development project. The HSIS is a 100 MBPS token passing fiber optic bus which services up to 256 stations and utilizes an IEEE 802.4-like token passing protocol. During 1986 the SAE AE-9B linear token passing bus protocol is being incorporated into the HSIS and down-sizing through the use of VLSI/VHSIC components is being examined. The HSIS system architecture and design allows for technology insertion and supports a wide range of equipment types and capabilities by the incorporation of firmware personality modules. Author

**A87-16734****AN ADVANCED PARAMETER ESTIMATION COPROCESSOR**

D. WONG, W. G. HOEFER, and M. F. FERNANDEZ (GE Electronics Laboratory, Syracuse, NY) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 112-118. refs

The architecture of a CORDIC-based coprocessor that efficiently implements critical, advanced parameter estimation functions is described and its performance is compared to a Fairchild 9450 (MIL-STD 1750A) processor. The coprocessor significantly increases the options of the system designer by offloading critical computationally intensive estimation tasks from the system's main processor, providing numerically stable matrix macrofunctions that can be used as building blocks for solutions to a broad range of problems and simultaneously increasing the throughput by an order of magnitude. This results in improved performance and increased accuracy since more realistic models with more states and greater update rates are now practical without adversely affecting other critical system functions. Author

**A87-16739****PHYSICAL LAYER CONSIDERATIONS FOR A HIGH THROUGHPUT, FIBER-OPTIC SERIAL HIGH-SPEED DATA BUS**

J. R. MACLEAN and R. W. UHLHORN (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 146-150. Research supported by the Harris Independent Research and Development Program.

The overall requirements of a high-throughput, serial, fiber-optic data bus for high performance military aircraft are discussed. Passive couplers and broadcast operation with up to 64 terminals force the selection of a star-coupled topology. The fiber-optic interconnect components are evaluated and loss projections made. High optical path loss, and the use of light-emitting diodes and pin-structure photodiodes require the receiver to be optimized for sensitivity and wide optical dynamic range. An ac-coupled design is capable of the highest sensitivity, but it requires an encoded data input for optimum sensitivity and minimum acquisition time. Signaling codes which minimize receiver time constants and maximize data throughput are examined. It is concluded that the best choice for all but very short message lengths is a modified 45 B block code plus NRZI. A 100 megabit per second data bus incorporating small, low power transmitters and receivers is feasible. Bus efficiency depends on message length. Author

**A87-16755****AN EXPERT SYSTEM FOR THE CONFIGURATION OF AIRCRAFT MODULAR VSCF GENERATOR SYSTEMS**

T.-L. HO, R. A. BAYLES, and E. R. SIEGER (Westinghouse Electric Corp., Baltimore, MD) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1986, p. 304-311.

The modular VSCF (Variable Speed Constant Frequency) electrical systems are designed using the latest technology and modular design techniques. The system is separated into standard modules to reduce the manufacturing cost and improve the product quality and services. This tool is an expert system which automatically configures the modules required for a particular application. The automatic configuration expert system is a rule-based synthesis system whose domain encompasses the matrix of standard modules. The configuration system is built by using a rule-based expert system development tool, OPS5, in a VAX 11/750 computer. It has the domain-specific knowledge necessary to configure the generators embedded in its rule-base and exhibits expertise to place the modules in the proper arrangement based on customer specifications and design criteria. Author

**A87-16763\* Draper (Charles Stark) Lab., Inc., Cambridge, Mass. ADVANCED INFORMATION PROCESSING SYSTEM - STATUS REPORT**

L. D. BROCK and J. LALA (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 368-375.

(Contract NAS9-16023; NASA TASK 84-18)

The Advanced Information Processing System (AIPS) is designed to provide a fault tolerant and damage tolerant data processing architecture for a broad range of aerospace vehicles. The AIPS architecture also has attributes to enhance system effectiveness such as graceful degradation, growth and change tolerance, integrability, etc. Two key building blocks being developed by the AIPS program are a fault and damage tolerant processor and communication network. A proof-of-concept system is now being built and will be tested to demonstrate the validity and performance of the AIPS concepts. Author

**A87-16778****CEPS - B-1B DIAGNOSTIC EXPERT SYSTEM**

K. DAVIS (Rockwell International Corp., Autonetics Strategic Systems Div., Anaheim, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 500-506. refs

(Contract F33657-81-C-0208)

CEPS (CITS Expert Parameter System) is one of the first large scale applications of an expert system to upgrade a major weapon system, the B-1B strategic aircraft. CEPS is a ground-based system that augments the on-board CITS (Central Integrated Test System) as a maintenance aid for both Organizational and Intermediate level technicians. Phase I of CEPS successfully demonstrated the utilization of expert system techniques for the isolation of fault ambiguities, and analysis and reduction of Retest Okays (RTOKs). Phase II consists of implementation of a prototype, including a five month period of usage by personnel at Dyess Air Force Base. Phase III will be the actual implementation of CEPS at all B-1B main operating bases. Author

**A87-16779****CAD/AI APPLICATIONS FOR AUTOMATED MANUFACTURING OF COMPOSITE STRUCTURES**

T. F. W. HALL (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1986, p. 508-511.

Aircraft designers are now routinely using many types of CAD systems as a powerful tool in generating their designs. This paper describes some of the design and manufacturing requirements peculiar to aircraft with composite material structure and the role that CAD systems can and do play in their production. It also emphasizes the fact that although, CAD systems are utilized in the composite area, artificial intelligence/expert systems will ultimately have to be incorporated in order to achieve the main goal of a fully automated manufacturing system. Author

**A87-16832#****EHF TEST MODEM/PROCESSOR (ETM/P)**

J. J. FOSHEE (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 1986; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 19-23, 1986. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1986, p. 1078-1083.

The components and operational features of two new military airborne command post satellite-based communications links are described. The Small EHF SHF Airborne Satellite Terminal (SESAST) is being evaluated on a C-135 flight test aircraft. The enhanced system includes a 20 HGz downlink, a new radome, a 20 HGz low noise amplifier, a wideband fast frequency hopping/dehopping capability, and a smaller travelling wave tube.

The ETM/P, to be added to the SESAST, consists of the EHF modem and processor, and ASR and printer, and a transec device. The baseband channel capability will be four each of primary transmit/receive channels, secondary channels, and primary receive only channels. M.S.K.

## A87-17735

### A PACK OF APPLIED PROGRAMS FOR AEROHYDRODYNAMICS GAMMA [PAKET PRIKLADNYKH PROGRAMM PO AERO-GIDRODINAMIKE GAMMA]

T. G. VOLKONSKAIA, V. M. PASKONOV, G. S. ROSLIAKOV, and M. V. SHUSTOVA. Moscow, Izdatel'stvo Moskovskogo Universiteta, 1985, 179 p. In Russian. refs

The systems and functional software contained in the applied program pack GAMMA are described. Particular topics discussed include the automation of numerical experiments, the architecture and the systems software of the GAMMA pack for solving problems in aerohydrodynamics, the data base management system, and automatic code generation for certain classes of problems. Examples of programs for calculating flows of viscous and nonviscous gases are presented. V.L.

**A87-17920\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### THE NEW LANGLEY RESEARCH CENTER ADVANCED REAL-TIME SIMULATION (ARTS) SYSTEM

D. J. CRAWFORD and J. I. CLEVELAND, II (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 18 p. (AIAA PAPER 86-2680)

Based on a survey of current local area network technology with special attention paid to high bandwidth and very low transport delay requirements, NASA's Langley Research Center designed a new simulation subsystem using the computer automated measurement and control (CAMAC) network. This required significant modifications to the standard CAMAC system and development of a network switch, a clocking system, new conversion equipment, new consoles, supporting software, etc. This system is referred to as the advanced real-time simulation (ARTS) system. It is presently being built at LaRC. This paper provides a functional and physical description of the hardware and a functional description of the software. The requirements which drove the design are presented as well as present performance figures and status. Author

## A87-17951#

### GRAPHICS IN CONCEPTUAL AIRCRAFT DESIGN - A DESIGNER'S VIEWPOINT

D. L. HAMMOND (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 15 p. refs (AIAA PAPER 86-2733)

The advantages and disadvantages of computer aided aircraft design relative to drawing board use are outlined. The advantages of computer aided design include the following: (1) volumes, surface areas, and centroids are easily calculated; (2) there is a decreased chance of inconsistencies between different views and cross sections; and (3) most three-dimensional shapes are generated faster. An aircraft designer's experience with graphics hardware, software, and maintenance is discussed. K.K.

## A87-18318

### APPLICATION OF A STATISTICAL METHOD OF FAULT DETECTION AND ISOLATION TO A FLIGHT CONTROL SYSTEM

K. S. RAO (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings. Tokyo, AGNE Publishing, Inc., 1984, p. 931-936. refs

This paper describes an application of Sequential Probability Ratio Technique (SPRT) of fault detection and isolation to a flight control problem using analytic redundancy. By comparing the outputs of the redundant sensors and applying SPRT technique on this, the FDI logic is initiated. Once a fault is detected, SPRT technique for each sensor chain is initiated on the error resulting from output of system dynamics modeled and the sensor output. By knowing these SPRT outputs, the sensor that has failed can be detected without any 'false alarm' and isolated. Digital simulations results are given to demonstrate the effectiveness of the technique. Author

## A87-18538#

### B-SURF (THREE-DIMENSIONAL CAD) SYSTEM FOR DESIGNING AND MANUFACTURING OF PRODUCTS WITH COMPLEX CONTOUR

R. ZHOU, X. LU, W. YAO, and L. WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, Aug. 1986, p. 417-421. In Chinese, with abstract in English. refs

The B-SURF three-dimensional CAD system is developed on the basis of computer aided design and the manufacturing of aircraft and automobiles. The system can perform many functions, including three-dimensional geometric design and calculation of contour values, three-dimensional graphic transformation and processing and NC drafting. The system, emphasizing the combination of pre- and post-processing, showed sufficiently the advantages of the method. Author

## A87-19238

### NON-ITERATIVE PARAMETER IDENTIFICATION TECHNIQUES

P. M. FITZSIMONS, V. R. P. JONNALAGADDA, B. H. TONGUE, and D. P. SCHRAGE (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 431-439. Research sponsored by the McDonnell Douglas Helicopter Co. refs

Assuming a linear and time-invariant model structure, descriptions of three different noniterative techniques that can be used to obtain parameter estimates are given. The techniques are deterministic (recursive) least squares, the extended Kalman filter, and the statistically linearized filter. The methods are used to identify the parameters of a one-state two-parameter system and a four-state twenty-four parameter system (taken from a linearized longitudinal model of an Advanced Light Helicopter in forward flight). K.K.

## A87-19242

### BASIC RESEARCH IN STRUCTURAL DYNAMIC SYSTEM IDENTIFICATION

S. HANAGUD, M. MEYYAPPA, and J. I. CRAIG (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 483-493. refs

A brief review of various system identification formulations employed in structural dynamic modeling is presented. Each approach is illustrated with an example. The advantages and disadvantages of using the different formulations are discussed. Application of identification techniques to rotorcraft related problems is considered with two additional examples. Numerical results are given to demonstrate the performance of the identification procedure in each case. Author

**N87-14041#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**A COMPUTER AIDED DESIGN (CAD) SYSTEM FOR THE DESIGN OF STIFFENED PANELS IN WING BOX STRUCTURES**

H. A. M. DANIELS 9 Apr. 1985 45 p  
(NLR-TR-85074-U; B8669020; ETN-86-98654) Avail: NTIS HC A03/MF A01

A computer aided system for designing compression panels in wing box structures is described. Application of the system yields optimal panels in the sense that they meet all the requirements imposed by the designer and have minimum weight per unit width. Weight reductions ranging from 0% to 10% are achieved compared to designs obtained in a conventional way by experienced designers. ESA

**N87-14061#** Air Force Armament Lab., Eglin AFB, Fla.  
**AN ANALYSIS OF ELLIPTIC GRID GENERATION TECHNIQUES USING AN IMPLICIT EULER SOLVER Interim Report, Oct. 1985 - Sep. 1986**

J. S. MOUNTS, A. MARTINEZ, and J. F. THOMPSON 9 Jun. 1986 12 p  
(AD-A169240; AFATL-TR-86-52) Avail: NTIS HC A02/MF A01 CSCL 12A

Several control function interpolation techniques in a general three-dimensional elliptic grid generation code and their effects on flow solutions using an implicit Euler algorithm are examined. These results will serve to guide the design of control function procedures and interpolation techniques in general grid generation codes. Three configurations and three grid types (O, C, and H grids) are examined. The results indicate that the selection of the control function interpolation techniques, which affect grid spacing, should be based on boundary curvature and spacing. The selection of the interpolation technique can then be made transparent to the user of general grid generation codes. Author (GRA)

**N87-14066#** Aeronautical Research Labs., Melbourne (Australia).

**A MODEL FOR THE EXTRACTION OF PERIODIC WAVEFORMS BY TIME DOMAIN AVERAGING**

P. D. MCFADDEN Mar. 1986 30 p  
(AD-A170688; ARL-AERO-PROP-TM-435) Avail: NTIS HC A03/MF A01 CSCL 12A

It is shown that the existing comb filter model of time domain averaging does not correctly describe the extraction of periodic waveforms from additive noise using a digital computer because it assumes a knowledge of the signal over an infinite time and the result it produces is not exactly periodic. A revised model is presented which requires only a finite number of samples and which produces a result which is periodic. It is demonstrated that the rejection of periodic noise of a known frequency can be optimized by the selection of a suitable number of averages. GRA

**N87-14258#** National Aerospace Lab., Tokyo (Japan).  
**AN EASILY VECTORIZABLE NUMERICAL SOLUTION OF THE EULER EQUATIONS**

K. MORINISHI, N. SATOFUKA, and H. NISHIDA *In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics* p 89-95 Nov. 1985 In JAPANESE; ENGLISH summary  
Avail: NTIS HC A12/MF A01

An efficient method was devised for solving the Euler equations. The method is based on a combination of the central finite difference approximation to the space variables with the rational Runge-Kutta time integration scheme. To improve the rate of convergence to the steady state solution, residual averaging and a multigrid technique are incorporated into the basic scheme. The algorithm is very simple to program, easily vectorized without any additional requirement such as extra memory, and easy to extend to multidimensional problems. A series of numerical experiments using the present method was performed on the quasi-one-dimensional nozzle flow problem with shock and two dimensional transonic flows over an airfoil. With the implicit residual averaging, the present method is stable until the Courant number

reaches about 50. The convergence rate does not monotonously improve as the Courant number is increased. The maximum efficiency for a steady state solution is achieved with a local Courant number of approximately 5. Numerical results for two dimensional transonic flow past airfoils indicate that the efficiency of the present method is just as good as that of the Beam Warming scheme.

Author

**N87-14270#** National Aerospace Lab., Tokyo (Japan).  
**DIRECT NUMERICAL CONTROL IN GRID GENERATION**

Y. KODAMA *In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics* p 209-216 Nov. 1985 In JAPANESE; ENGLISH summary  
Avail: NTIS HC A12/MF A01

A grid generation scheme is proposed. In this scheme, several plausible geometrical conditions which should be satisfied by a grid are listed, and then, starting with an initial grid, modifications are made iteratively to the grid, until those conditions are satisfied. The present scheme is called a geometrical method, in contrast to the existing algebraic and partial differential equation approaches. The geometrical conditions listed in the 2-D case are: clustering in the eta-direction; orthogonalization near the solid wall; smooth spacing distribution in the xi-direction; smooth spacing distribution in the eta-direction; smooth curvature distribution in the eta-direction; smooth curvature in the xi-direction; minimum spacing in the xi-direction; and minimum spacing in the eta-direction. The conditions are realized by simple algorithms, and are combined with suitable weighting factors. Several examples of 2-D geometries are shown, such as a NACA0012 wing section with angle of attack, a NACA0012 wing section with a spoiler and a flap, and a circular cylinder both for C-grid and O-grid. Extension to 3-D is straightforward and will soon be published. Author

**N87-14910\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ADAPTIVE INVERSE CONTROL FOR ROTORCRAFT VIBRATION REDUCTION Ph.D. Thesis**

S. A. JACKLIN Oct. 1985 192 p  
(NASA-TM-86829; A-85396; NAS 1.15:86829) Avail: NTIS HC A09/MF A01 CSCL 620

The Least Mean Square (LMS) algorithm is extended to solve the multiple-input, multiple-output problem of alleviating N/Rev helicopter fuselage vibration by means of adaptive inverse control. A frequency domain locally linear model is used to represent the transfer matrix relating the high harmonic pitch control inputs to the harmonic vibration outputs to be controlled. By using the inverse matrix as the controller gain matrix, an adaptive inverse regulator is formed to alleviate the N/Rev vibration. The stability and rate of convergence properties of the extended LMS algorithm are discussed. It is shown that the stability ranges for the elements of the stability gain matrix are directly related to the eigenvalues of the vibration signal information matrix for the learning phase, but not for the control phase. The overall conclusion is that the LMS adaptive inverse control method can form a robust vibration control system, but will require some tuning of the input sensor gains, the stability gain matrix, and the amount of control relaxation to be used. The learning curve of the controller during the learning phase is shown to be quantitatively close to that predicted by averaging the learning curves of the normal modes. It is shown that the best selections of the stability gain matrix elements and the amount of control relaxation is basically a compromise between slow, stable convergence and fast convergence with increased possibility of unstable identification. Author

## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

**A87-17991\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**MODELING THE EFFECTS OF WIND TUNNEL WALL ABSORPTION ON THE ACOUSTIC RADIATION CHARACTERISTICS OF PROPELLERS**

K. J. BAUMEISTER (NASA, Lewis Research Center, Cleveland, OH) and W. EVERSMAN (Missouri-Rolla, University, Rolla) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 19 p. Previously announced in STAR as N86-29630. refs (AIAA PAPER 86-1876)

Finite element theory is used to calculate the acoustic field of a propeller in a soft walled circular wind tunnel and to compare the radiation patterns to the same propeller in free space. Parametric solutions are present for a 'Gutin' propeller for a variety of flow Mach numbers, admittance values at the wall, microphone position locations, and propeller to duct radius ratios. Wind tunnel boundary layer is not included in this analysis. For wall admittance nearly equal to the characteristic value of free space, the free field and ducted propeller models agree in pressure level and directionality. In addition, the need for experimentally mapping the acoustic field is discussed. Author

**A87-19243\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**APPLICATION OF THE CEPSTRUM TO REMOVE ECHOS FROM ROTOR ACOUSTIC SPECTRA**

R. M. MARTIN (NASA, Langley Research Center, Hampton, VA) and C. L. BURLEY (PRC Kentron International, Hampton, VA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 503-512. refs

The application of the power cepstrum technique to the analysis of model scale helicopter rotor noise spectra is investigated. The power cepstrum technique emerges as a useful tool for the removal of undesired acoustic reflections from measured rotor spectra. It is most effective when the reflections are exact duplicates of the signal, i.e., when the echo transfer function is linear. Moreover, the technique is best applied to a measured spectrum which is due entirely to the signal and its echoes, when no nonsource related signals are present. It is noted that this technique can be applied without prior knowledge of the echo characteristics. K.K.

**A87-19244\*** Boeing Vertol Co., Philadelphia, Pa.

**THE ROLE OF WIND TUNNEL MODELS IN HELICOPTER NOISE RESEARCH**

H. STERNFELD, JR. and E. G. SCHAEFFER (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 513-523. refs

(Contract NAS2-10767)

A study was conducted to determine the applicability of using small-scale powered helicopter models operating in nonanechoic wind tunnels to predict the sound pressure levels of full-scale rotor harmonic noise components. The investigation included noise generation due to high-tip-speed effects, tandem-rotor blade/vortex interactions, single rotors operating on test towers, and the interaction between main rotor vortices and tail rotors. In all cases it was found that the pressure time history waveforms characteristic of different noise-generating mechanisms were properly reproduced by the models. Corrections for microphone locations, acoustical reverberation, and tunnel wind velocity were developed. Application of these corrections to the model data were found to yield

satisfactory correlation with full-scale sound pressure levels except for the isolated single rotor, where highly transient data, both model and full-scale, precluded good agreement of absolute values.

Author

**A87-19245\*** Cornell Univ., Ithaca, N.Y.

**PROGRESS IN TAIL ROTOR NOISE ANALYSIS**

S.-T. CHOU and A. R. GEORGE (Cornell University, Ithaca, NY) IN: American Helicopter Society, Annual Forum, 42nd, Washington, DC, June 2-4, 1986, Proceedings. Volume 1. Alexandria, VA, American Helicopter Society, 1986, p. 535-549. NASA-supported research. refs

Helicopter tail rotor noise generated by interactions with the main rotor tip vortices and with the fuselage separation mean wake is investigated. The tail rotor blade-main rotor tip vortex interaction is modeled as an airfoil of infinite span cutting through a moving vortex. The present results are compared to the tail rotor loading and high speed thickness noise and are found to be significant. This noise mechanism is a function of the helicopter operating conditions and the location of the tail relative to the main rotor. Tail rotor self-generated noise due to turbulent vortex shedding from blunt trailing edges is also analyzed. K.K.

**N87-14120\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECTS OF BACKGROUND NOISE ON TOTAL NOISE ANNOYANCE**

K. F. WILLSHIRE Jan. 1987 59 p (NASA-TP-2630; L-16153; NAS 1.60:2630) Avail: NTIS HC A04/MF A01 CSCL 46A

Two experiments were conducted to assess the effects of combined community noise sources on annoyance. The first experiment baseline relationships between annoyance and noise level for three community noise sources (jet aircraft flyovers, traffic and air conditioners) presented individually. Forty eight subjects evaluated the annoyance of each noise source presented at four different noise levels. Results indicated the slope of the linear relationship between annoyance and noise level for the traffic noise was significantly different from that of aircraft and of air conditioner noise, which had equal slopes. The second experiment investigated annoyance response to combined noise sources, with aircraft noise defined as the major noise source and traffic and air conditioner noise as background noise sources. Effects on annoyance of noise level differences between aircraft and background noise for three total noise levels and for both background noise sources were determined. A total of 216 subjects were required to make either total or source specific annoyance judgements, or a combination of the two, for a wide range of combined noise conditions. Author

**N87-14957\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**HIGH-SPEED PROPELLER NOISE PREDICTIONS: EFFECTS OF BOUNDARY CONDITIONS USED IN BLADE LOADING CALCULATIONS**

M. NALLASAMY (Sverdrup Technology, Inc., Cleveland, Ohio.), B. J. CLARK, and J. F. GROENEWEG 1987 26 p Presented at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by AIAA

(NASA-TM-88913; E-3337; NAS 1.15:88913; AIAA-87-0525) Avail: NTIS HC A03/MF A01 CSCL 20A

The acoustics of an advanced single rotation SR-3 propeller at cruise conditions are studied employing a time-domain approach. The study evaluates the acoustic significance of the differences in blade pressures computed using nonreflecting rather than hard wall boundary conditions in the three-dimensional Euler code solution. The directivities of the harmonics of the blade passing frequency tone and the effects of chordwise loading on tone directivity are examined. The results show that the maximum difference in the computed sound pressure levels due to the use of blade pressure distributions obtained with the nonreflecting rather than the hard wall boundary conditions is about 1.5 dB. The blade



passing frequency tone directivity obtained in the present study shows good agreement with jetstar flight data. Author

**N87-14958#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Technische Akustik.

**NOISE CERTIFICATION AND NOISE SENSITIVITY STUDIES ON THE BO-105 HELICOPTER**

W. R. SPLETTSTOESSER, K. P. ANDERS, and K. H. SPIEGEL Jun. 1985 109 p In GERMAN; ENGLISH summary (DFVLR-MITT-86-13; ISSN-0176-7739; ETN-86-98752) Avail: NTIS HC A06/MF A01; DFVLR, Cologne, West Germany DM 34

Noise measurements were performed on the BO-105 helicopter in compliance with the International Civil Aviation Organization (ICAO) standard for noise certification. The measurement procedure, and the noise data acquisition, analysis, and reduction, as well as the applied correction procedures are described. The Effective Perceived Noise Levels (EPNL) were evaluated and related to the proposed ICAO noise limits. Additional noise tests were conducted by varying flight and operational parameters such as gross weight, flight altitude, air speed, and rotor speed beyond the range specified by the standard. The sensitivity of the EPNL to these parameters is discussed. ESA

**N87-14960#** Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).

**NOISE DEVELOPMENT IN TRANSONIC FLOWS AT THE IMPACT OF VORTICES ON A PROFILE LEADING EDGE Thesis [SCHALLENTSTEHUNGSMECHNISMEN IN TRANSSONISCHEN STROEMUNGEN BEIM AUFTREFFEN VON WIRBELN AUF EINE PROFILVORDERKANTE]**

H. M. LENT May 1986 61 p In GERMAN (MPIS-5/1986; ISSN-0436-1199; ETN-87-98866) Avail: NTIS HC A04/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 36

The production of noise in the interaction of a vortex with the leading edge of a profile in a transonic flow was investigated. The occurring phenomena are detected in the far field as noise (blade-vortex interaction noise). The vortex was produced as a von Karman vortex street in the wake of a rectangular cylinder. The interferograms show a strong shock-like pressure wave in a broad parameter range after the passing of the leading edge by the vortex; this is probably the most important mechanism of the down stream pulse noise as, e.g., observed for helicopters and can thus easily be simulated in experiments. The development of weaker shocks at the profile were also observed downstream; this phenomenon does not seem to be important for the noise production. The measurement of the pressure distribution in the unsteady potential flow shows similarities with the theory with respect to the dipole-like noise radiation characteristic; however there are significant differences in the details, probably due to the neglect of compressibility and friction. ESA

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### SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

**A87-17888#**

**INNOVATIONS IN AIRCRAFT SYSTEMS MANAGEMENT TO MEET 1990-2000 REQUIREMENTS**

S. N. MULLIN (Lockheed-California Co., Burbank) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. refs (AIAA PAPER 86-2629)

**A87-17890#**

**AIRCRAFT INTERACTIVE SYSTEM MANAGEMENT - FROM PENCILS TO COMPUTERS**

T. G. BAXTER (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 11 p. (AIAA PAPER 86-2631)

Management of the many interactive disciplines associated with the avionics, armament, aerodynamics, structures, fuel systems, environmental controls, flight controls, auxiliary power, life support systems, antennas, lighting, electrical systems, landing systems, and propulsion systems to evolve a highly integrated system is a necessity for current and future aircraft weapon delivery systems. This paper describes an interactive system management and system integration effort to satisfy the requirements for the design and development of a modern aircraft weapon delivery system. Current system integration procedures, which involve very complex electronics using VHSIC, emphasize computer software, use electronic and software integration laboratories, and involve engineering development functional fixtures, are discussed.

Author

**A87-17912#**

**ECONOMICS IN NEW COMMERCIAL AIRCRAFT DESIGN**

A. L. JACOBSON and C. M. TSUBAKI (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. (AIAA PAPER 86-2667)

An evaluation is made of design engineering influences on the relative economic advantage of a new commercial aircraft by comparison with competing aircraft. Tradeoff studies and preliminary cost analyses are employed to ensure that the selected design will be an outstanding compromise between product quality, production cost, and operating costs. Attention is given to direct operating costs and the specific case of a 2-ft wing extension design feature for a 110-seat aircraft based on the DC-9-30.

O.C.

**A87-17928#**

**SURVIVABILITY/VULNERABILITY INFORMATION ANALYSIS CENTER (SURVIAC) - A TOOL FOR THE AIRCRAFT SURVIVABILITY COMMUNITY**

J. M. VICE (Booz, Allen and Hamilton, Inc., Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 8 p. (AIAA PAPER 86-2691)

The Survivability/Vulnerability Information Analysis Center (SURVIAC) is a Department of Defense Information Analysis Center (DOD IAC) serving the survivability community in the technical area of nonnuclear survivability and lethality. SURVIAC maintains libraries, databases and survivability models which are within its technical area. Services provided to the aircraft survivability community include responses to bibliographic and technical inquiries, copies of aircraft survivability models and performance of special tasks. The SURVIAC resources available to assist the aircraft survivability community are described along with procedures for use of SURVIAC. Author

**A87-17936#**

**A COMMERCIAL VIEW OF HYBRID AIRSHIPS**

C. G. WHITTENBURY (Erickson Air Crane Co., Marysville, CA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 4 p. (AIAA PAPER 86-2703)

The practical business and operational characteristics required of hybrid airships for industrial and commercial heavy lift operations are summarized. Experience from Skycrane applications in logging, construction, and the movement of heavy machinery has been used to develop these requirements. Three main business factors are considered: economics, performance in a job, and practicability. Capital and operational costs are related to the basic design characteristics of heavy lift aircraft to illustrate the requirements imposed from commercial considerations. Observations about

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possible development directions for a commercially-relevant hybrid program are included. Author

### A87-17959#

#### THE FUTURE OF THE NATIONAL AIRSPACE SYSTEM

A. G. MORGAN, JR. (Delta Air Lines, Inc., Atlanta, GA) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 6 p.  
(AIAA PAPER 86-2743)

Issues related to the improvement of the ATC system are examined. The need for a new method of centralized flow control of traffic, and the disadvantages of mandatory capacity constraints are considered. The role of the FAA in the development of an efficient airspace system with regard to user's requirements is discussed. I.F.

### A87-17960#

#### NOISE REDUCTION ABATEMENT AND MITIGATION - A HISTORY OF NOISE CONTROL PROGRAMS AND REVIEW OF THE REGULATORY PROCESS

B. D. HARTMAN (St. Louis, Missouri Airport Authority, MO) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 29 p.  
(AIAA PAPER 86-2745)

The noise mitigation regulatory process and the history of noise mitigation programs are reviewed, and the direct and indirect costs that can be attributed to the noise mitigation measures are analyzed. The issues of funding availability for large airports are discussed along with policies, legal responsibility, airport access, capacity/delay, and fleet modernization are discussed. The aspect of relating these issues with the local attempts to achieve control over what should be perceived as a national problem are considered. The funding availability data for large airports are presented. I.S.

### A87-17961#

#### ROTORCRAFT PRELIMINARY DESIGN EDUCATION

D. P. SCHRAGE and S. A. MEYER (Georgia Institute of Technology, Atlanta) AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology Meeting, Dayton, OH, Oct. 20-22, 1986. 7 p. refs  
(AIAA PAPER 86-2748)

Since rotorcraft are complex aircraft and multidisciplinary in nature the Georgia Tech philosophy has been to use a graduate rotorcraft design course to provide a synthesis for the academic curriculum and to introduce the graduate students to the multidisciplinary nature of their research. The two-quarter graduate rotorcraft design course has proved to be very effective, and has served as a catalyst for establishing a broader graduate program in aerospace-systems design. This paper describes how the graduate rotorcraft design course has been developed and implemented in providing rotorcraft preliminary design education. Author

### A87-19297

#### THE FAA 'BUY-SELL' SLOT RULE - AIRLINE DEREGULATION AT THE CROSSROADS

R. M. HARDAWAY (Denver, University, CO) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 52, Fall 1986, p. 1-75. refs

The economic and legal consequences of the FAA Buy-Sell Rule (BSR) are analyzed. The benefits of airline deregulation and the effects of airport access limitation on airline deregulation are discussed. The economic and legal status of airport resources, such as gates, terminal, and landing slots, are examined in order to study slot allocation based on airport resources. Methods of resources allocation which include gate and terminal leases, scheduling committees, lotteries, landing fees, and administrative regulations are described. Consideration is given to the disadvantages of BSR, and antitrust enforcement under BSR. It is noted that the BSR is more beneficial for allocating slots than other methods; however, the possibility of anticompetitive behavior is significant. I.F.

### A87-19298

#### PILOT CERTIFICATE ACTIONS AND CIVIL PENALTIES

A. ARMSTRONG Journal of Air Law and Commerce (ISSN 0021-8642), vol. 52, Fall 1986, p. 77-92. refs

Legal principles and government policies regarding pilot certificate actions are discussed. The procedures involved in the analysis of an aircraft accident are described. The types of sanctions which can be imposed on the pilot, reprimand, certificate actions, and civil actions, are examined. Consideration is given to the NTSB hearing and the potential for appeals by the pilots. I.F.

### A87-19300

#### RECENT DEVELOPMENTS IN AVIATION CASE LAW

R. D. MARGO (Condon and Forsyth; California, University, Los Angeles) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 52, Fall 1986, p. 117-190. refs

Cases concerned with the liability aspects of aviation litigations are analyzed. Consideration is given to jurisdiction on the federal and personal levels, and the liabilities of air carriers, manufacturers, and the U.S. government. The awarding of damages based on mental anguish and emotional distress, post-traumatic stress disorders, and preimpact and post-impact pain and suffering, and the types of insurance policies available to air carriers are examined. I.F.

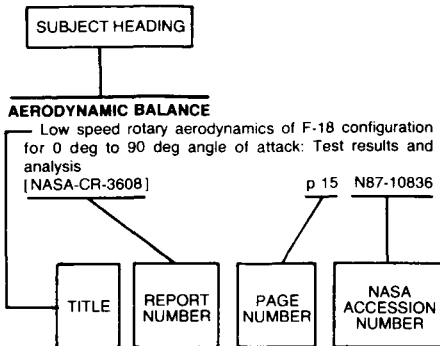
### N87-14252# National Aerospace Lab., Tokyo (Japan).

#### ON A DATA BASE SYSTEM FOR NUMERICAL SIMULATOR

T. ISHIZUKA, H. MIYOSHI, and T. AKI In its Proceedings of the 3rd NAL Symposium on Aircraft Computational Aerodynamics p 33-41 Nov. 1985 In JAPANESE; ENGLISH summary  
Avail: NTIS HC A12/MF A01

The necessity for computer simulation in research and development in aeronautics and astronautics has increased at a rapid pace in recent years. In particular, sophisticated large and fast computers are required to perform simulations at a practical level. The National Aerospace Laboratory of Japan is now promoting a numerical simulator project (NS project), which includes the introduction of a supercomputer. As a part of this project, a data base system was constructed for the purpose of managing input and test data necessary for numerical simulation and allowing many different kinds of utilization. The summary of this data base system and the functions of operational commands employed in the system are explained from the viewpoint of the user. Firstly, data available in this system are considered. Secondly, ways of creating a data base system that meets the demands of the field of numerical simulation are discussed. Thirdly, major features of the operational commands are explained. Finally, a list of operational commands and examples are presented. Author

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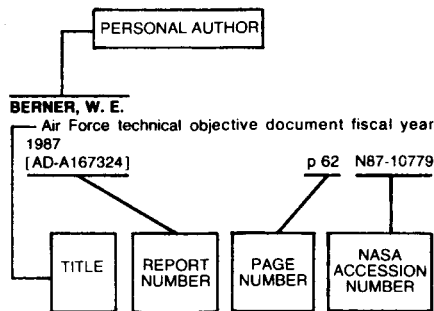
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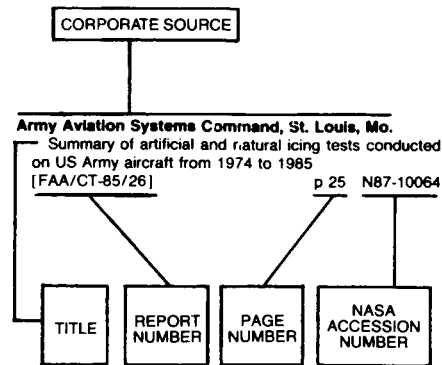
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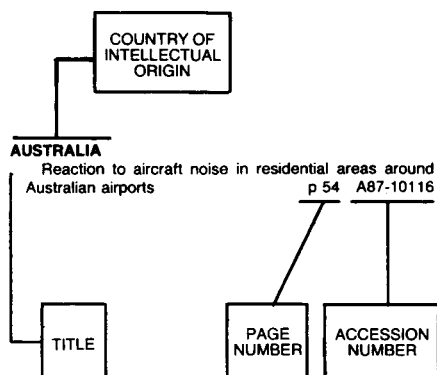
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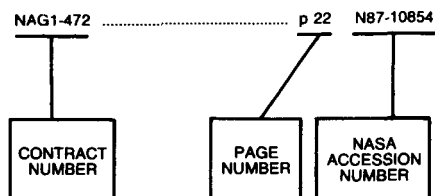
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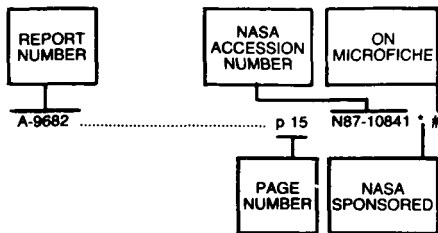
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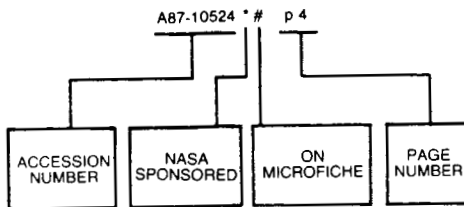


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